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Water Quality of Streams Tributary to Lakes Superior and Michigan

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By

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ABSTRACT

Water quality of streams tributary to Lakes Superior and Michigan was analyzed for 142 stations on 99 streams tributary to Lake Superior and 83 stations on 56 streams tributary to Lake Michigan during 1962-65.

Concentrations of aluminum, copper, and iron were not affected greatly by flow or season. Magnesium, calcium, chlorides, total alkalinity, total hardness, and conductivity varied with the flow, temperature, and season; the lowest values were during the spring runoff and heavy rains, and the highest were during low water in late summer and the colder periods of winter. Concentrations of nitrate, silica, and sulfates were lowest in the spring and summer. Concentrations of tanninlike and ligninlike compounds were highest during the spring runoff and other high-water periods, and were lowest during freezeup when surface runoff was minimal. The pH values were highest from June to September and lowest during the spring runoff. Phenolphthalein alkalinity was detected primarily in the summer and coincided occasionally with low flows just before the spring thaw. Total hardness usually was lower in streams tributary to Lake Superior than in streams tributary to Lake Michigan. The total hardness was higher in the streams in Wisconsin than in the streams in Michigan along the west shore of Lake Michigan. It was lowest in the northernmost streams.

The water quality of the streams in an area was related to the geological characteristics of the land.

INTRODUCTION

A study of the water quality of streams tributary to Lakes Superior and Michigan was made in conjunction with control of the sea lamprey, Petromyzon marinus, in the Great Lakes. The primary purpose was to observe the natural levels and seasonal fluctuations in concentrations of aluminum, copper, iron, magnesium, calcium, chloride, nitrate, nitrite, silica, sulfate, tanninlike and ligninlike compounds, phenolphthalein alkalinity, total alkalinity, and total hardness, and in values of pH and conductivity. A secondary purpose was to determine the variation in water quality of streams from different geological regions in the drainages of Lakes Superior and Michigan.

The Bureau of Commercial Fisheries and the Fisheries Research Board of Canada have used the selective larvicide, TFM (3-trifluoromethyl-4-nitrophenol), in the control of the sea lamprey (Applegate, Howell, Moffett, Johnson, and Smith, 1961). The toxicity of TFM is influenced by physical and chemical properties of water. The amount of TFM required to kill larval lampreys increases as alkalinity, conductivity, and pH increase. The degree of selectivity of TFM between ammocetes and other fishes and the amount of toxicant required vary with seasons, and from stream to stream and location within the stream (Howell and Marquette, 1962). A method for the estimation of the biological activity of TFM by its relation to properties of water has been determined (Kanayama, 1963).

In late 1962 three streams tributary to Lake Superior and three tributary to Lake Michigan were selected for collection of surface water at 2- to 4-week intervals for information on seasonal variation. The Chocolay, Big Garlic, and Little Garlic Rivers were chosen for Lake Superior and the Ford, Pensaukee, and Ahnapee Rivers for Lake Michigan. In addition, water was collected for analyses of the chemical characteristics before treatment with TFM of streams tributary to the two lakes. Other streams were sampled when time permitted.

This report includes information from samples taken at various times from August 1962 through December 1965 for 142 stations

on 99 streams tributary to Lake Superior and 83 stations on 56 Lake Michigan tributaries.

MATERIALS AND METHODS

Water samples were taken from midstream in 1-liter polyethylene bottles and held in these containers until analyses were completed. The polyethylene bottles were rinsed with river water before they were filled.

Analyses of water usually were completed within 8 hours after collection but not later than 30 hours. If the analyses could not be completed on the day of collection, the samples were stored in a refrigerator and studied the following day. Water samples were warmed to 21° C. (70° F.), and turbid samples were passed through Whatman No. 12 filter paper prior to analyses.

Determinations for aluminum, copper, and iron were made as soon as possible after samples were collected.

Determinations were limited to analytical procedures adaptable to field use. A Hach DR photoelectric colorimeter[1] was used for colorimetric measurements.

The following analytical procedures were used:

Temperature (° C.)--Water temperatures were taken to the nearest ° F. with a hand or pocket thermometer at the time of sampling and converted to ° C.

Aluminum (Al)--Determinations were made by the aluminon method (Hach Chemical Company, 1963).

Copper (Cu)--Copper was determined by the cuprethol method (Hach Chemical Company, 1963).

Iron (Fe)--The 1, 10-phenanthroline method was used for iron determinations (Hach Chemical Company, 1963).

Magnesium (Mg^{++})--Magnesium was calculated as the difference between total hardness and calcium.

Calcium (Ca^{++})--The EDTA titrimetric method was used (American Public Health Association, 1960).

Chloride (Cl^-)--Chloride was determined by the mercuric nitrate method (American Public Health Association, 1960).

Nitrate (NO_3^-)--Determinations were made by the brucine method (American Public Health Association, 1960).

Nitrite (NO_2^-)--The sulfanilic acid - 1, naphthylamine method was used (Hach Chemical Company, 1963).

Silica (SiO_2)--Determinations were made by the silicomolybdate method (Hach Chemical Company, 1963).

Sulfate ($SO_4^=$)--The turbidimetric method was used to determine sulfate (Hach Chemical Company, 1963).

Tannin and lignin--Determinations were made by the tyrosine method (Hach Chemical Company, 1963).

pH--A Beckman Zeromatic pH meter was used to measure pH.

Alkalinity--Phenolphthalein and total alkalinities were determined by titration (American Public Health Association, 1960).

Hardness--Total hardness was determined by EDTA titration method (American Public Health Association, 1960).

Conductivity--Conductivity was measured at 20° C. (68° F.) and corrected to 18° C. (64° F.) by correction factors given by Smith (1962). Measurements were made with an Industrial Instruments, Model RC-16B2, conductivity bridge.

The streams where water samples were collected were numbered in geographical sequence from east to west along the south shore of Lake Superior (fig. 1) and counterclockwise starting from the northeast shore at the outlet of Lake Michigan (fig. 2). The number of each stream is used to identify the stream in the tables. The locations where water samples were taken on each stream are given in the Appendix. The asterisks designate the streams where more than one location was sampled.

CHOCOLAY RIVER AND MAJOR TRIBUTARIES, MARQUETTE COUNTY, MICH.

The Chocolay River, a tributary to Lake Superior, was sampled at four locations in Marquette County, Mich. The main stem of the Chocolay River and its three major tributaries, Big Creek, Cedar Creek, and Cherry Creek, accounted for 85 to 90 percent of the volume at the mouth. The flow varied from 3.5 to 7.1 $m.^3$/sec. (125 to 250 c.f.s.), but flows were higher during the spring runoff or heavy rains. The main stream is 26 km. (16 miles) long and has 208 km. (129 miles) of tributary streams, and drains about 412 $km.^2$ (159 sq. miles) (Brown, 1944).

The flow of the main stem of the Chocolay River usually ranged from 0.8 to 2.0 $m.^3$/sec. (30 to 70 c.f.s.), but discharges were higher during the spring runoff and heavy rains. The water was usually clear, light to moderate color, and slightly alkaline. Turbidity and color increased during rapid runoff.

Water quality data were collected on the main stem of the Chocolay River at the U.S. Highway 41 bridge from December 1962 through December 1965) (table 1). Concentrations of calcium, total alkalinity, and total hardness, and conductivity readings were lowest during the spring runoff and other periods of increased

[1] Trade names referred to in this publication do not imply endorsement of the commercial products.

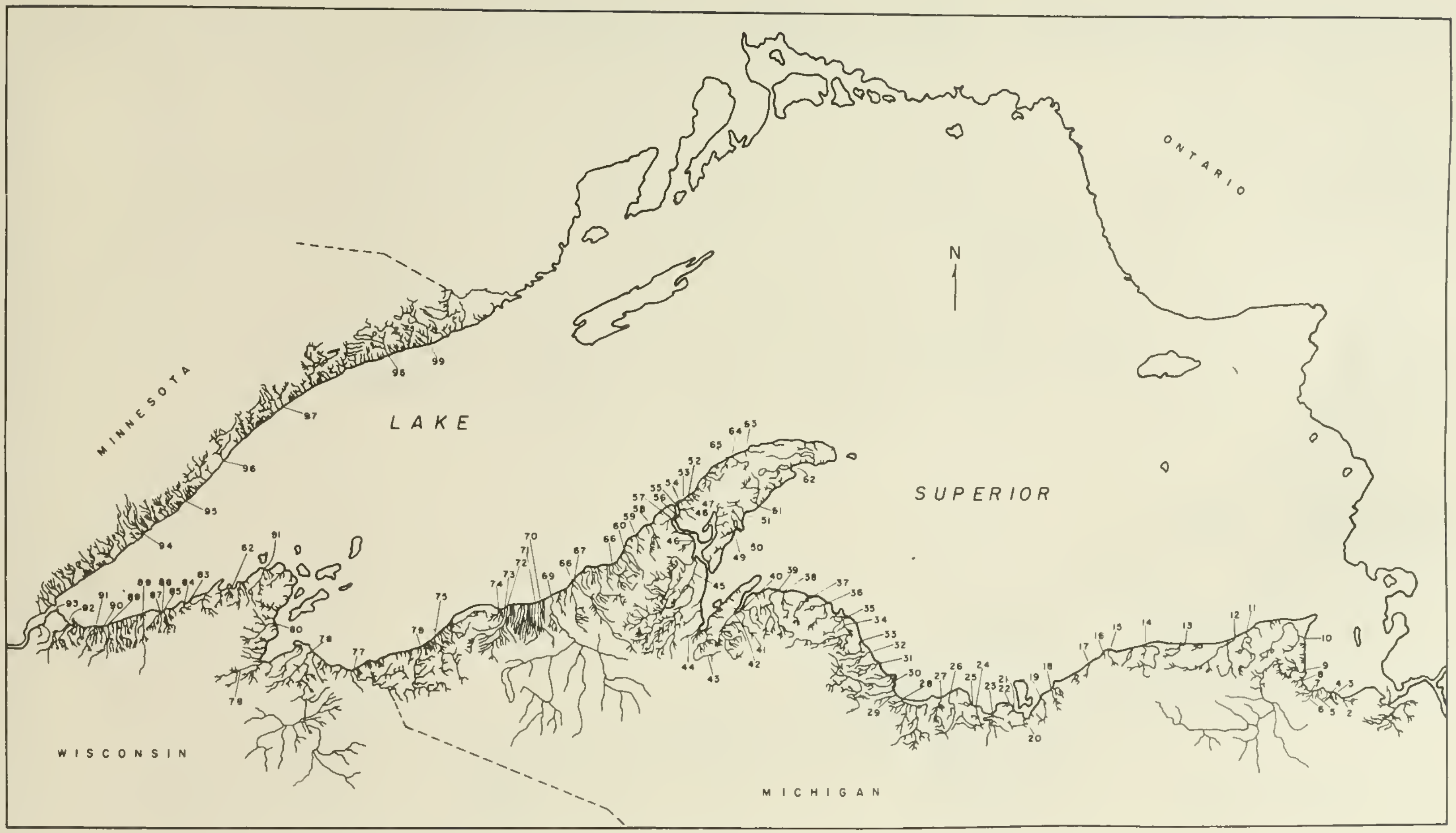

Figure 1.--Location of Lake Superior streams where water samples were collected.

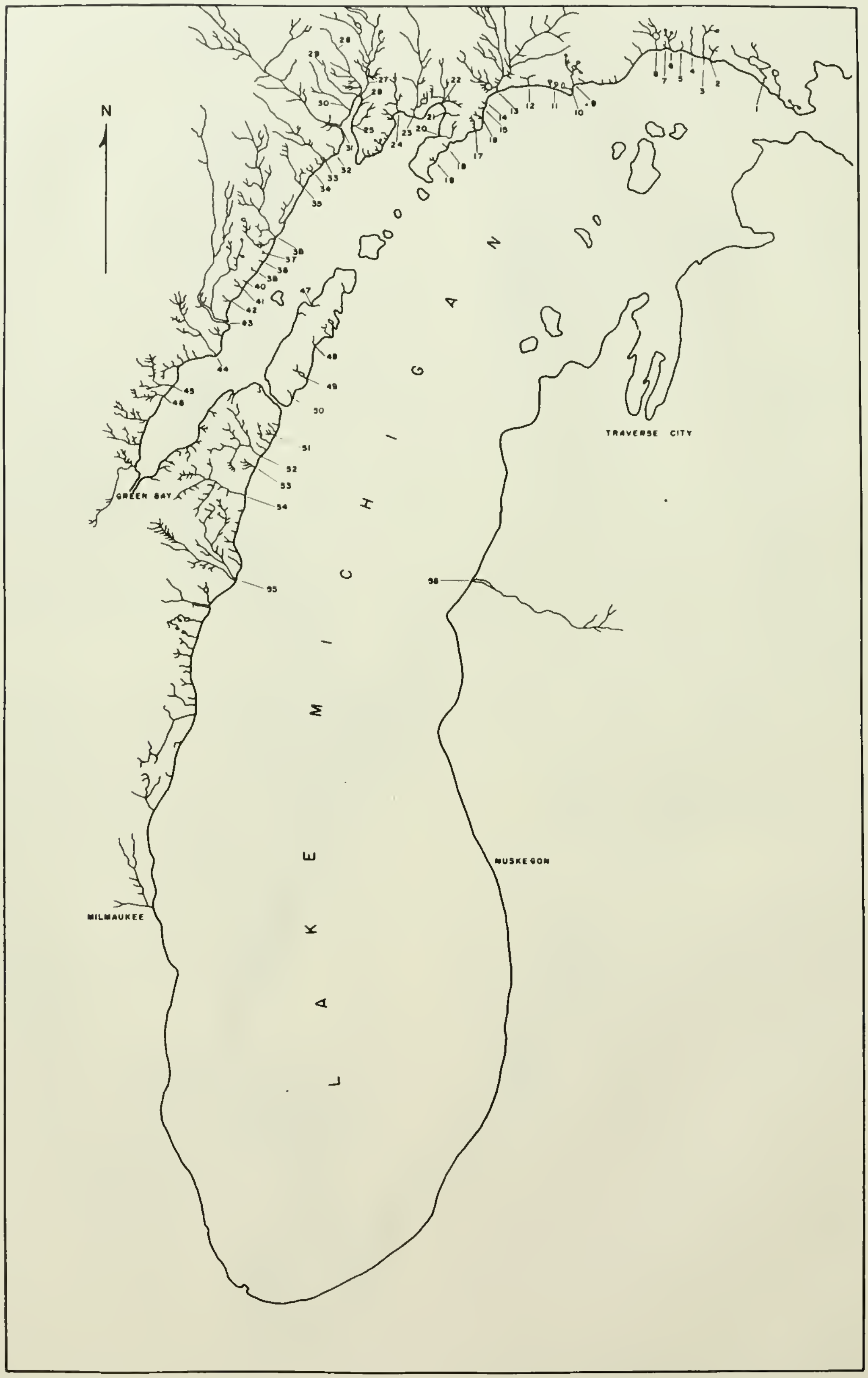

Figure 2.--Location of Lake Michigan streams where water samples were collected.

Table 1.--Water Quality of the Chocolay River, Marquette County, Mich., 1962-65

[Water samples were taken at U.S. Highway 41 bridge.]

Date	Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-nesa	Conductivity (micromhoa/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/5	3	0.15	0.10	0.20	4.9	16	...	1.9	0.00	4.0	23	1.0	7.6	0	45	60	106
12/17	0	0.10	...	0.10	5.8	18	...	2.9	0.00	6.0	19	0.6	7.6	0	53	68	119
1963																	
1/14	0	0.15	0.10	0.10	4.9	21	...	2.6	0.00	8.0	22	0.4	7.6	0	63	72	136
1/28	0	0.10	0.10	0.10	5.8	21	...	2.4	0.00	9.0	18	0.3	7.4	0	66	76	138
2/19	0	0.10	0.10	0.10	5.3	23	...	2.8	0.00	10.0	20	0.3	7.7	0	70	80	149
3/4	0	0.10	0.10	0.10	5.3	21	...	3.3	0.00	9.0	19	0.2	7.6	0	66	74	136
3/18	1	0.10	0.10	0.10	5.8	22	...	2.9	0.01	8.0	20	0.2	7.8	0	66	78	144
4/2	2	0.23	0.10	0.15	2.9	9	3.0	1.4	0.00	3.0	11	2.0	7.2	0	22	34	66
4/25	4	...	...	0.10	5.3	14	2.5	...	...	3.0	12	1.5	7.4	0	42	58	97
5/20	8	...	...	...	5.3	18	2.0	...	...	...	8	...	7.4	0	56	66	115
6/5	16	...	0.08	0.10	5.8	21	2.5	...	...	5.0	8	...	7.6	0	66	76	134
7/9	12	...	0.10	0.12	5.3	21	3.0	...	...	6.0	10	...	7.7	0	64	74	143
8/19	12	...	0.06	0.10	5.8	20	3.0	...	...	6.0	6	...	7.7	0	66	74	133
9/17	14	...	0.07	0.15	5.3	23	3.0	...	...	4.0	10	0.3	7.5	0	74	80	149
10/17	11	0.09	0.08	0.05	4.9	23	3.5	2.6	0.00	7.0	9	0.4	7.6	0	72	78	149
11/18	7	0.13	0.08	0.15	4.4	20	4.0	1.7	0.00	5.0	21	1.4	7.3	0	50	68	126
12/9	1	0.11	...	...	4.9	18	3.5	...	0.00	...	...	...	7.5	0	44	64	119
1964																	
1/13	1	0.03	0.06	0.16	4.9	22	3.0	2.7	0.01	9.0	11	0.5	7.6	0	66	76	144
2/4	0	0.07	0.05	0.13	3.9	22	3.0	3.0	0.00	8.0	15	0.5	7.4	0	62	72	135
3/4	0	0.12	0.07	0.20	4.9	20	4.5	1.5	0.00	8.0	15	0.6	7.3	0	56	70	136
3/24	4	...	0.07	0.09	3.9	22	5.0	3.0	0.00	8.0	14	0.4	7.3	0	60	70	138
5/4	11	...	0.05	0.19	3.4	14	3.0	2.0	0.01	2.5	13	2.3	7.5	0	36	48	89
7/8	17	...	...	0.15	3.9	22	3.0	...	...	7.0	8	0.5	7.8	0	66	72	139
8/4	18	...	...	0.24	4.4	19	4.0	2.1	0.00	3.5	10	2.4	7.8	0	54	66	117
9/3	15	...	...	0.12	4.4	22	3.0	1.9	0.00	3.0	10	1.1	7.9	0	64	72	132
10/21	7	...	...	0.17	5.3	19	4.5	...	...	4.0	10	1.3	7.9	0	56	70	129
11/24	1	...	...	0.10	4.4	20	3.5	2.8	0.01	7.0	10	1.1	7.6	0	58	68	127
12/15	0	...	...	0.20	5.3	19	3.5	1.7	0.00	8.0	14	0.8	7.8	0	58	70	127
1965																	
1/27	0	...	...	0.14	4.9	22	3.5	3.3	0.00	8.0	7	0.6	7.7	0	64	74	139
2/26	0	...	...	0.15	5.3	21	3.5	2.9	0.01	8.5	10	0.3	7.7	0	66	74	141
3/16	2	...	...	0.14	5.1	22	4.0	3.3	0.01	7.0	12	1.3	7.9	0	64	76	135
4/12	1	...	...	0.23	4.6	12	3.5	2.9	0.00	4.0	15	1.1	7.4	0	30	48	87
5/6	11	0.13	0.06	0.23	5.3	11	3.5	1.7	0.01	2.0	17	2.1	7.6	0	30	50	80
6/7	16	0.09	0.03	0.19	4.9	19	3.5	2.2	0.00	4.0	10	1.7	7.9	0	58	68	124
6/30	11	0.04	0.04	0.11	5.3	22	3.5	2.9	0.01	5.0	12	0.4	7.4	0	66	76	139
7/27	13	0.04	0.06	0.10	4.9	23	3.0	3.4	0.02	6.5	12	0.4	7.7	0	66	78	146
8/17	15	0.02	0.05	0.14	5.3	22	3.5	3.9	0.01	7.5	13	0.2	8.0	0	68	78	153
9/20	11	0.08	0.02	0.19	5.3	20	4.0	1.9	0.00	4.5	23	1.7	7.8	0	50	72	129
10/12	6	0.08	0.01	0.17	5.8	20	4.5	2.3	0.01	4.5	24	1.5	7.6	0	52	74	119
11/3	4	0.12	0.06	0.14	4.9	18	4.0	2.7	0.01	5.5	9	1.4	7.7	0	50	66	124
12/8	1	0.13	0.05	0.11	4.9	18	3.0	2.5	0.00	6.5	15	1.1	7.8	0	48	62	120

flow. These values increased as the flow receded to summer levels, decreased again during fall rains, but became high again when flows were low in winter. Chlorides were lower during the spring runoff, but were nearly constant the remainder of the year. Chlorides were higher in 1964 and 1965 than in 1963. Nitrite was seldom present in the early period of the study but was found in many samples in the later period. Concentrations of tanninlike and ligninlike compounds were highest when flows increased, especially during the spring runoff, but dropped as the flow receded; concentrations were low in the winter. The pH values were low during the spring runoff and rose slowly in the summer to a level that was maintained until spring. The pH values dropped when the flow increased. Phenolphthalein alkalinity was zero for all samples. Ranges for values of selected measurements were: magnesium, 2.9 to 5.8 p.p.m.; calcium, 9 to 23 p.p.m.; pH, 7.2 to 8.0; total alkalinity, 22 to 74 p.p.m.; total hardness, 34 to 80 p.p.m.; and conductivity, 66 to 153 micromhos. Water temperature varied from 0° to 18° C. (32° to 64° F.).

Big Creek had a flow of 1.1 $m.^3$/sec. (40 c.f.s.) that varied little except for higher flows during the spring runoff. The water was clear, cool, slightly alkaline, and had little or no color or turbidity except during the spring runoff.

Water quality data were collected from December 1962 through December 1965 at the U.S. 41 bridge (table 2). Concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were lower during the spring runoff and remained nearly constant the rest of the year. Chlorides remained low throughout the year. Nitrite and phenolphthalein alkalinity were not detected. Concentrations of tanninlike and ligninlike compounds were highest in the spring and were low or zero the rest of the year. The pH values were lower during the spring runoff but changed little during the rest of the year. The ranges for values of selected measurements were as follows ("usual ranges" are given for measurements that varied only during the spring runoff): magnesium, 3.4. to 6.3 p.p.m.; calcium, 16 to 26 p.p.m., usually 22 to 26 p.p.m.; pH, 7.3 to 8.1; total alkalinity, 46 to 80 p.p.m., usually 70 to 80 p.p.m.; total hardness, 58 to 88 p.p.m., usually 78 to 88 p.p.m.; and conductivity, 99 to 154 micromhos, usually 142 to 154 micromhos. Water temperature varied from 1° to 12° C. (33° to 53° F.).

The flow of Cedar Creek was about 0.7 $m.^3$/sec. (24 c.f.s.) and varied little except for higher flows during the spring runoff. The water was clear, cool, slightly alkaline, and had little or no color or turbidity except during the spring runoff.

Water quality data were collected from December 1962 through December 1965 at the U.S. Highway 41 bridge (table 3). Concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were lower during the spring runoff and were nearly constant the rest of the year. Chlorides remained low throughout the year. Nitrite was not detected. Concentrations of tanninlike and ligninlike compounds were highest during the spring runoff and were low or zero the rest of the year. The pH values were lower during the spring runoff and when flows were higher. The pH values changed little during the rest of the year. Phenolphthalein alkalinity was zero for all samples. The ranges for values of selected measurements were (usual ranges are given for measurements that varied only during the spring runoff): magnesium, 3.4 to 6.3 p.p.m.; calcium, 16 to 22 p.p.m., usually 20 to 22 p.p.m.; pH, 7.4 to 8.1; total alkalinity, 48 to 68 p.p.m., usually 64 to 66 p.p.m.; total hardness, 54 to 76 p.p.m., usually 68 to 72 p.p.m.; and conductivity, 96 to 135 micromhos, usually 120 to 127 micromhos. Water temperature varied from 1° to 12° C. (33° to 53° F.).

The flow of Cherry Creek was about 0.7 $m.^3$/sec. (25 c.f.s.) and varied little except flows were slightly higher during the spring runoff. The water was usually clear, cool, slightly alkaline, and had little or no color.

Water quality information was collected at the U.S. Highway 41 bridge from December 1962 through December 1965 (table 4). Concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were nearly constant throughout the year, but values were slightly lower during the spring runoff. Chlorides remained low throughout the study. Nitrite was not present. Tanninlike and ligninlike compounds were present during the spring runoff and periods of rain. Early in the study, pH remained below 8.0 but was usually above 8.0 in the latter half of 1964 and most of 1965. Phenolphthalein alkalinity was not detected. The ranges for values of selected measurements were (usual ranges are given for measurements that varied only during the spring runoff): magnesium, 4.9 to 7.8 p.p.m.; calcium, 23 to 26 p.p.m., usually 25 to 26 p.p.m.; pH, 7.6 to 8.3; total alkalinity, 70 to 82 p.p.m., usually 80 to 82 p.p.m.; total hardness, 80 to 96 p.p.m., usually 84 to 90 p.p.m.; and conductivity, 142 to 156 micromhos, usually 151 to 156 micromhos. Water temperature varied from 1° to 11° C. (33° to 51° F.).

LITTLE GARLIC RIVER, MARQUETTE COUNTY, MICH.

The Little Garlic River, a tributary to Lake Superior, was sampled at County Road 550 bridge in Marquette County, Mich. The main stream is 10 km. (6 miles) long and has 23 km. (14 miles) of small tributaries and a drainage area of about 31 $km.^2$ (12 sq. miles).

Table 2.--Water quality of Big Creek (tributary to Chocolay River), Marquette County, Mich., 1962-65

[Water samples were taken at U.S. Highway 41 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^{=}$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/5	4	0.10	0.10	0.10	5.8	22	...	2.7	0.00	8.0	18	0.0	7.9	0	72	80	142
12/17	3	0.05	...	0.10	5.8	24	...	3.1	0.00	9.0	19	0.0	7.8	0	76	84	150
1963																	
1/14	1	0.05	0.10	0.01	6.3	24	...	2.9	0.00	10.0	18	0.0	7.8	0	77	86	151
1/28	1	0.05	0.10	0.10	5.8	24	...	2.0	0.00	10.0	16	0.0	7.7	0	76	84	149
2/19	1	0.07	0.10	0.01	6.3	24	...	2.9	0.00	10.0	19	0.0	7.9	0	78	86	149
3/4	4	0.10	0.10	0.05	5.8	24	...	2.7	0.00	10.0	20	0.0	7.8	0	78	84	149
3/18	2	0.05	0.10	0.05	5.8	25	...	2.6	0.00	10.0	9	0.1	7.9	0	78	86	151
4/2	3	0.13	0.05	0.10	4.6	16	2.0	1.4	0.00	5.0	9	1.4	7.3	0	46	58	99
4/25	5	...	...	0.10	5.3	25	1.0	...	...	9.0	8	0.1	7.6	0	78	84	148
5/20	7	...	...	...	6.3	24	1.0	...	...	...	4	...	7.7	0	78	86	149
6/5	11	...	0.08	0.08	6.3	25	0.5	...	...	9.0	5	...	7.8	0	80	88	150
7/9	9	...	0.10	0.06	5.8	26	1.0	...	...	11.0	8	...	7.8	0	80	88	151
8/19	9	...	0.09	0.06	6.3	24	1.0	...	...	10.0	5	...	7.8	0	80	86	152
9/17	10	...	0.08	0.03	5.3	26	1.5	...	...	9.0	7	0.0	7.4	0	80	86	153
10/17	9	0.09	0.10	0.07	5.3	25	1.0	2.2	0.00	10.0	5	0.0	7.7	0	80	84	152
11/18	7	0.05	0.08	0.05	5.8	25	1.0	2.5	0.00	10.0	9	0.1	7.6	0	78	86	151
12/9	3	0.05	...	...	5.3	22	1.0	...	0.00	...	...	...	7.8	0	70	78	140
1964																	
1/13	2	0.01	0.07	0.01	5.3	26	1.0	2.9	0.00	11.0	7	0.1	7.8	0	78	86	149
2/4	2	0.02	0.04	0.07	5.3	26	1.0	3.8	0.00	11.0	9	0.1	7.6	0	76	86	148
3/4	3	0.07	0.08	0.04	4.4	25	1.0	2.5	0.00	10.0	7	0.1	7.6	0	74	80	145
3/24	6	...	0.07	0.03	5.3	26	1.5	2.8	0.00	9.0	10	0.0	7.6	0	76	86	148
5/4	9	...	0.08	0.02	4.9	24	1.0	3.1	0.00	9.0	11	0.6	7.9	0	74	80	146
7/8	11	...	...	0.03	5.8	25	1.0	...	...	10.0	5	0.0	7.9	0	80	86	152
8/4	12	...	...	0.02	5.3	25	1.0	2.7	0.00	8.0	4	0.5	8.0	0	80	84	152
9/3	11	...	...	0.09	5.8	25	1.0	1.7	0.00	8.0	5	0.0	8.0	0	80	86	149
10/21	7	...	...	0.07	5.3	24	1.0	...	...	9.0	10	0.2	8.0	0	78	82	145
11/24	3	...	...	0.08	5.8	24	1.0	2.7	0.00	10.0	11	0.2	7.9	0	78	84	150
12/15	2	...	...	0.08	5.3	25	1.0	2.8	0.00	11.0	10	0.0	8.0	0	78	84	150
1965																	
1/27	2	...	...	0.09	5.8	24	1.0	3.3	0.00	10.0	12	0.0	7.9	0	78	84	148
2/26	1	...	...	0.12	5.8	25	1.0	2.4	0.00	10.0	10	0.0	8.0	0	80	86	151
3/16	4	...	...	0.11	4.9	25	1.5	2.9	0.00	10.0	13	0.7	8.1	0	78	82	147
4/12	3	...	...	0.12	3.4	21	1.5	2.3	0.00	8.0	12	0.4	7.7	0	56	66	118
5/6	11	0.06	0.04	0.10	4.9	22	1.5	3.3	0.00	7.5	13	0.7	8.0	0	70	76	135
6/7	11	0.06	0.05	0.11	4.9	26	1.0	1.3	0.00	9.5	10	0.3	7.9	0	78	84	149
6/30	8	0.04	0.02	0.07	5.8	25	1.0	2.0	0.00	9.0	8	0.1	8.0	0	80	86	152
7/27	10	0.02	0.04	0.04	5.3	26	0.7	1.9	0.00	10.0	10	0.2	7.9	0	80	86	153
8/17	11	0.02	0.04	0.03	6.3	25	1.0	1.8	0.00	10.0	11	0.0	8.0	0	80	88	154
9/20	9	0.03	0.07	0.11	5.3	24	1.0	1.8	0.00	10.0	13	0.6	7.9	0	72	82	146
10/12	7	0.02	0.04	0.10	6.3	24	1.0	2.0	0.00	9.5	12	0.1	7.8	0	78	86	151
11/3	6	0.03	0.05	0.03	4.9	26	1.0	2.3	0.00	10.0	8	0.2	7.9	0	78	84	150
12/8	4	0.01	0.03	0.10	5.8	24	1.0	2.2	0.00	10.0	8	0.1	8.0	0	76	84	149

Table 3.--Water quality of Cedar Creek (trihutary to Chocolay River), Marquette County, Mich., 1962-65

[Water samples were taken at U.S. Highway 41 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^{-}	NO_3^{-}	NO_2^{-}	SiO_2	$SO_4^{=}$	Tannin snd lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.3 at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/5	4	0.10	0.10	0.01	4.9	19	...	1.1	0.00	7.0	15	0.0	7.8	0	63	68	121
12/17	4	0.05	0.10	0.01	5.3	19	...	0.9	0.00	8.0	18	0.0	7.7	0	63	70	125
1963																	
1/14	1	0.05	0.10	0.10	4.4	20	...	1.5	0.00	9.0	17	0.0	7.8	0	64	68	121
1/28	1	0.05	0.10	0.01	4.9	20	...	0.8	0.00	9.0	15	0.0	7.7	0	66	70	129
2/19	1	0.08	0.10	0.01	5.3	20	...	1.2	0.00	8.0	16	0.0	7.9	0	66	72	123
3/4	4	0.05	0.10	0.01	5.3	20	...	0.9	0.00	8.0	17	0.0	7.8	0	66	72	123
3/18	2	0.05	0.10	0.05	6.3	20	...	0.6	0.00	9.0	5	0.0	7.9	0	66	76	124
4/2	4	0.10	0.07	0.15	3.4	16	1.0	0.8	0.00	5.0	5	1.0	7.4	0	48	54	96
4/25	5	...	...	0.03	5.3	21	1.0	...	...	8.0	4	0.2	7.6	0	66	74	125
5/20	7	...	...	...	4.4	22	1.0	...	...	...	1	...	7.8	0	67	72	124
6/4	10	...	0.10	0.08	5.3	22	0.5	...	...	8.0	5	...	7.9	0	66	76	135
7/9	9	...	0.10	0.09	5.3	21	1.0	...	...	8.0	6	...	7.7	0	66	70	123
8/19	9	...	0.07	0.04	4.9	20	1.5	...	...	9.0	4	...	7.9	0	66	70	124
9/17	9	...	0.08	0.07	4.9	20	1.0	...	...	7.5	7	0.0	7.6	0	68	70	127
10/17	9	0.08	0.09	0.08	3.9	21	1.0	0.4	0.00	8.0	5	0.0	7.7	0	66	68	125
11/18	7	0.06	0.06	0.10	3.9	21	1.5	0.7	0.00	8.0	5	0.0	7.6	0	64	68	122
12/9	3	0.07	...	...	4.4	20	1.0	...	0.00	...	...	...	7.9	0	62	68	120
1964																	
1/13	2	0.00	0.07	0.01	3.9	21	1.0	1.1	0.00	9.5	4	0.1	7.8	0	64	68	125
2/4	3	0.06	0.05	0.03	4.9	21	1.0	2.1	0.00	9.0	6	0.1	7.7	0	66	72	123
3/4	3	0.02	0.08	0.11	4.4	19	1.2	0.8	0.00	8.0	11	0.3	7.7	0	62	66	119
3/24	7	...	0.05	0.02	4.4	20	1.5	0.5	0.00	7.0	4	0.0	7.7	0	64	68	120
5/4	9	...	0.07	0.03	4.4	20	2.0	2.0	0.00	7.0	6	0.5	8.0	0	64	68	125
7/8	11	...	...	0.07	4.4	20	1.0	...	...	7.0	3	0.3	8.0	0	66	68	124
8/4	11	...	...	0.00	4.9	20	1.0	1.4	0.00	8.0	7	0.0	8.0	0	66	70	124
9/3	12	...	...	0.02	4.4	20	1.0	0.3	0.00	8.0	7	0.0	8.0	0	66	68	125
10/21	7	...	...	0.02	4.4	20	1.0	...	...	7.0	4	0.4	7.9	0	64	68	122
11/24	4	...	...	0.10	4.4	20	1.0	0.7	0.00	9.0	4	0.1	7.8	0	66	68	122
12/15	2	...	...	0.07	4.4	20	1.0	0.7	0.00	10.0	10	0.0	8.0	0	64	68	122
1965																	
1/27	2	...	...	0.00	4.4	20	1.0	1.2	0.00	8.0	4	0.1	7.9	0	66	68	122
2/26	1	...	...	0.03	4.9	20	1.0	0.8	0.00	7.0	5	0.0	7.9	0	64	70	123
3/16	5	...	...	0.10	3.9	21	1.5	1.6	0.00	9.0	8	0.4	8.1	0	64	68	120
4/12	4	...	...	0.09	3.4	20	1.0	0.9	0.00	6.0	7	0.1	7.8	0	58	64	117
5/6	11	0.05	0.04	0.04	3.9	20	2.0	1.3	0.00	6.0	11	0.4	8.1	0	60	66	118
6/7	11	0.02	0.04	0.10	4.4	20	1.0	0.3	0.00	7.0	6	0.4	8.0	0	66	68	121
6/30	8	0.04	0.03	0.09	4.4	20	1.0	0.4	0.00	8.5	4	0.0	7.9	0	64	68	124
7/27	10	0.03	0.04	0.07	4.9	20	0.5	0.3	0.00	8.0	5	0.3	7.9	0	66	70	124
8/17	10	0.04	0.05	0.10	4.9	20	1.0	0.5	0.00	9.0	6	0.0	8.0	0	66	70	125
9/20	8	0.00	0.05	0.02	4.4	20	1.0	0.5	0.00	8.5	5	0.1	8.0	0	64	68	123
10/12	6	0.01	0.05	0.07	4.4	21	1.0	0.4	0.00	9.0	6	0.0	7.8	0	64	70	123
11/3	6	0.03	0.01	0.01	4.4	20	1.0	0.7	0.00	8.0	5	0.2	7.9	0	64	68	123
12/8	4	0.01	0.07	0.15	4.4	20	1.5	0.7	0.00	10.0	6	0.0	8.0	0	64	68	122

Table 4.--Water quality of Cherry Creek (tributary to Chocolay River), Marquette County, Mich., 1962-65

[Water samples were taken at U.S. Highway 41 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.^{3} at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/5	4	0.05	0.10	0.00	5.8	24	...	0.9	0.00	9.0	17	0.0	7.9	0	79	84	154
12/17	4	0.10	0.10	0.00	6.3	25	...	0.8	0.00	9.0	19	0.0	7.7	0	79	88	154
1963																	
1/14	1	0.07	0.10	0.01	4.9	26	...	0.9	0.00	9.0	18	0.0	7.9	0	80	84	154
1/28	1	0.05	0.10	0.00	5.8	25	...	0.8	0.00	10.0	16	0.0	7.8	0	82	86	154
2/19	2	0.05	0.10	0.00	6.8	25	...	0.8	0.00	9.0	16	0.0	7.9	0	82	90	154
3/4	4	0.05	0.05	0.05	6.3	25	...	0.7	0.00	8.0	18	0.0	7.9	0	80	88	154
3/18	3	0.05	0.10	0.05	5.8	26	...	0.3	0.00	9.0	8	0.0	7.9	0	82	88	154
4/2	6	0.10	0.07	0.05	5.3	23	2.0	1.6	0.00	6.0	11	0.6	7.7	0	70	80	142
4/25	6	...	...	0.05	6.3	26	1.5	...	...	8.0	9	0.1	7.8	0	81	90	156
5/20	7	...	...	...	5.8	26	1.5	...	...	...	4	...	7.8	0	82	88	154
6/4	9	...	0.08	0.04	7.8	26	1.0	...	...	9.0	5	...	7.9	0	82	96	156
7/9	8	...	0.09	0.00	5.8	26	1.5	...	...	9.0	5	...	7.8	0	82	88	154
8/19	9	...	0.08	0.06	5.8	26	2.0	...	...	9.5	5	...	7.9	0	82	88	155
9/17	9	...	0.06	0.06	5.8	26	2.5	...	...	9.0	8	0.0	7.7	0	82	88	155
10/17	9	0.05	0.09	0.07	6.3	25	2.0	0.5	0.00	10.0	7	0.0	7.8	0	80	88	156
11/18	8	0.05	0.07	0.05	6.3	26	2.0	0.8	0.00	9.0	7	0.0	7.6	0	82	90	156
12/9	4	0.05	...	...	6.8	25	1.5	...	0.00	...	...	...	8.0	0	80	90	151
1964																	
1/13	3	0.02	0.08	0.10	5.1	26	1.5	0.8	0.00	11.0	7	0.1	7.8	0	82	86	154
2/4	4	0.03	0.06	0.09	5.8	26	1.5	2.0	0.00	10.0	12	0.1	7.7	0	80	88	154
3/4	4	0.03	0.09	0.04	5.3	26	2.0	0.7	0.00	8.5	11	0.4	7.8	0	80	86	152
3/24	8	...	0.07	0.02	5.3	26	2.0	0.7	0.00	9.0	6	0.0	7.8	0	80	88	154
5/4	8	...	0.08	0.05	5.3	25	1.0	1.7	0.00	8.0	9	0.3	8.0	0	82	84	156
7/8	10	...	...	0.02	5.8	25	1.5	...	...	9.0	6	0.1	8.0	0	82	86	154
8/4	10	...	...	0.04	5.3	26	1.5	1.4	0.00	9.0	14	0.0	8.0	0	82	86	154
9/3	11	...	...	0.09	5.3	25	1.0	0.4	0.00	8.0	7	0.1	8.1	0	80	84	151
10/21	7	...	...	0.00	5.8	25	1.5	...	...	7.0	5	0.4	8.0	0	80	86	151
11/24	4	...	...	0.05	5.8	25	1.5	0.7	0.00	9.0	8	0.2	7.9	0	80	86	154
12/15	3	...	...	0.00	5.8	25	1.5	0.6	0.00	9.0	7	0.0	8.1	0	80	86	154
1965																	
1/27	3	...	...	0.06	5.3	26	1.5	0.9	0.00	9.0	10	0.1	8.0	0	82	86	154
2/26	1	...	...	0.10	5.8	26	1.5	0.9	0.00	8.0	12	0.0	8.0	0	82	88	155
3/16	6	...	...	0.04	5.3	26	2.0	1.2	0.00	9.0	14	0.2	8.2	0	80	86	151
4/12	5	...	...	0.10	5.8	25	1.5	0.7	0.00	8.0	9	0.0	8.0	0	78	86	152
5/6	11	0.00	0.06	0.09	5.8	25	1.5	0.7	0.00	8.0	14	0.1	8.3	0	76	86	150
6/7	11	0.03	0.04	0.08	4.9	26	1.0	0.3	0.00	8.5	12	0.3	8.2	0	80	86	151
6/30	8	0.03	0.04	0.09	6.3	25	1.0	0.4	0.00	8.0	9	0.0	8.0	0	82	88	149
7/27	9	0.03	0.04	0.08	5.8	25	1.5	0.4	0.00	9.5	14	0.0	7.8	0	80	86	154
8/17	9	0.05	0.03	0.01	5.3	26	1.0	0.5	0.00	8.0	8	0.0	8.0	0	80	86	156
9/20	8	0.00	0.05	0.03	5.8	26	1.5	1.0	0.00	9.5	14	0.1	8.0	0	78	88	154
10/12	7	0.00	0.04	0.05	5.8	26	1.0	0.3	0.00	7.5	13	0.0	7.9	0	78	88	151
11/3	6	0.01	0.03	0.01	5.8	26	1.5	0.7	0.00	9.0	12	0.3	8.0	0	80	88	154
12/8	5	0.03	0.03	0.00	5.8	26	1.5	0.4	0.00	9.5	5	0.0	8.0	0	80	88	156

The flow usually ranged from 0.1 to 0.4 m.^{3}/sec. (3 to 15 c.f.s.), but the discharges were higher during the spring runoff. The water was clear, slightly alkaline, and had a light color. The turbidity and color were higher during increased flows.

Water quality data were collected from January 1963 through December 1965 (table 5). Aluminum, copper, iron, and magnesium concentrations remained low most of the year. Concentrations of calcium, total alkalinity, and total hardness, and conductivity readings were lowest during the spring runoff and when flow increased. The highest values were in late summer or fall when the flow decreased. Chlorides remained low throughout the study. Concentrations of nitrate and sulfate were low in the summer. Nitrite and phenolphthalein alkalinity were zero for all samples. Concentrations of silica were highest in late summer and winter and lowest in spring and early summer. Concentrations of tanninlike and ligninlike compounds were highest during the spring runoff and when the flow increased, but dropped as the flow receded. The lowest values were in the winter. The pH values were lowest during the spring runoff and highest in late summer. The ranges for values of selected measurements were: magnesium, 1.5 to 5.3 p.p.m.; calcium, 8 to 26 p.p.m.; nitrate, 0.1 to 2.2. p.p.m.; silica, 3.0 to 8.5 p.p.m.; sulfate, 2 to 22 p.p.m.; pH, 7.1 to 8.0; total alkalinity, 18 to 78 p.p.m.; total hardness, 26 to 82 p.p.m.; and conductivity, 48 to 146 micromhos. Water temperatures varied from 0° to 22° C. (32° to 72° F.).

BIG GARLIC RIVER, MARQUETTE COUNTY, MICH.

The Big Garlic River, a tributary to Lake Superior, was sampled at County Road 550 bridge in Marquette County, Mich. The main stream is 10 km. (6 miles) long and has 66 km. (41 miles) of tributary streams and a drainage area of 80 km.^{2} (31 sq. miles) (Brown, 1944). The flow of the Big Garlic River usually ranged from 0.3 to 3.3 m.^{3}/sec. (9 to 117 c.f.s.), but discharges were higher during the spring runoff. The water was clear, slightly alkaline, and had light to moderate color, although turbidity and color were higher during increased flows.

Water quality data were collected from August 1962 through December 1965 (table 6). Aluminum, copper, and iron concentrations remained low throughout the year. Magnesium concentrations dropped during the spring runoff and varied little the remainder of the year. Concentrations of calcium, total alkalinity, and total hardness, and conductivity readings were lowest during the spring runoff. These values increased as the flow decreased and were highest in late summer and fall. Chlorides remained low throughout the study. Concentrations of nitrate were low from May to November. Nitrite and phenolphthalein alkalinity were not detected. Silica was highest when flows were low in late summer and winter. Sulfate concentrations were highest in winter. Tanninlike and ligninlike compounds were highest during the spring runoff and when flow increased but dropped as the flow decreased. The pH values were lowest during the spring runoff and at other times when flows increased. The ranges for values of selected measurements were: magnesium, 1.5 to 5.8 p.p.m.; calcium, 6 to 20 p.p.m.; nitrate, 0.1 to 2.9 p.p.m.; silica, 3.0 to 9.5 p.p.m.; sulfate, 3 to 22 p.p.m.; pH, 7.0 to 7.9; total alkalinity, 14 to 62 p.p.m.; total hardness, 20 to 66 p.p.m.; and conductivity, 40 to 124 micromhos. Water temperatures varied from 0° to 21° C. (32° to 70° F.).

FORD RIVER, DELTA COUNTY, MICH.

The Ford River, a tributary to Lake Michigan, has its origin in Dickinson County and flows through Marquette and Menominee Counties to its mouth in Delta County, Mich. The main stream is 179 km. (111 miles) long and has 407 km. (253 miles) of tributary streams and a drainage area of 1,225 km.^{2} (473 sq. miles) (Brown, 1944). The U.S. Geological Survey (1964) reported an average flow of 9.7 m.^{3}/sec. (342 c.f.s.) for 1954-60; the yearly average ranged from 6.6 to 18.0 m.^{3}/sec. (233 to 640 c.f.s.). The water was clear, slightly alkaline, and moderately colored. Turbidity and color became higher when flows increased.

Water quality data were collected from December 1962 through December 1965 (table 7): regularly at State Highway M-95 bridge; intermittently at County Road 581 bridge in Dickinson County; bridge in section 19, 5 km. (3 miles) west of Woodlawn, Mich.; and the mouth of the Ford River. Aluminum, copper, and iron concentrations varied little throughout the year. Concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were lowest during the spring runoff and when flow increased. These values increased as the flow decreased and were highest in winter and late summer. Chlorides were low during the spring runoff and high when flows were low in late summer. Concentrations of nitrate, silica, and sulfates were lowest in the summer. Nitrite was recorded on four occasions. Concentrations of tanninlike and ligninlike compounds were lowest in the winter and highest during the spring runoff and when flows increased. The pH values were lowest during the spring runoff and highest when flows were low in summer and fall. Phenolphthalein alkalinity was in two samples. The ranges for values of selected measurements were: magnesium, 7.8 to 27.0

Table 5.--Water quality of the Little Garlic River, Marquette County, Mich., 1963-65

[Water samples were taken at County Road 550 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1963																	
1/9	1	0.10	0.10	0.20	3.4	17	...	0.6	0.00	6.0	22	0.7	7.7	0	47	56	102
1/23	0	0.10	0.10	0.20	3.4	19	...	0.9	0.00	5.0	18	0.4	7.5	0	54	62	113
2/5	0	0.10	0.10	0.20	4.4	22	...	1.0	0.00	8.0	19	0.2	7.7	0	60	72	121
2/26	0	0.10	0.10	0.20	4.4	22	...	0.9	0.00	8.0	19	0.0	7.6	0	62	72	125
3/12	0	0.10	0.10	0.20	4.4	22	...	0.8	0.00	8.0	10	0.2	7.7	0	62	72	129
3/27	1	0.15	0.10	0.20	3.2	13	1.0	1.2	0.00	6.0	9	1.0	7.4	0	34	46	77
4/8	2	0.17	0.08	0.10	2.4	8	1.0	1.0	0.00	4.0	7	1.5	7.1	0	20	30	48
4/23	3	0.15	0.10	0.10	2.4	11	1.0	0.4	0.00	4.0	11	1.2	7.3	0	28	38	72
5/20	10	0.10	...	0.15	3.4	14	1.0	0.3	0.00	4.0	5	0.8	7.4	0	40	48	81
6/4	16	0.14	0.08	0.10	2.4	13	1.0	0.4	0.00	4.0	5	1.3	7.4	0	36	42	72
6/27	16	0.15	0.05	0.13	2.9	16	1.0	0.4	0.00	5.0	4	0.6	7.3	0	44	52	89
7/10	15	0.07	0.08	0.12	3.9	21	1.5	0.4	0.00	6.0	7	0.5	7.6	0	62	68	120
7/26	19	0.12	0.10	0.12	4.4	22	1.5	0.2	0.00	6.0	4	0.4	7.7	0	68	74	129
8/20	14	0.06	0.03	0.15	3.9	22	2.0	0.3	0.00	4.5	6	0.6	7.7	0	66	72	125
9/19	14	0.05	0.08	0.12	3.9	23	1.0	0.2	0.00	6.0	5	0.4	7.6	0	70	74	135
10/3	12	0.07	0.07	0.11	3.9	26	2.0	0.2	0.00	6.0	4	0.4	7.4	0	76	80	144
10/16	11	0.07	0.08	0.09	4.4	26	1.0	0.2	0.00	8.5	6	0.6	7.5	0	78	82	146
11/14	3	0.10	0.06	0.23	3.4	21	1.0	0.5	0.00	7.0	11	0.4	7.4	0	58	66	116
12/6	0	0.09	0.06	0.50	3.9	22	1.5	0.5	0.00	6.0	13	0.5	7.5	0	58	70	124
1964																	
1/8	0	0.06	0.01	0.18	3.1	20	1.5	0.8	0.00	5.0	9	0.6	7.6	0	52	62	111
1/27	0	0.07	0.06	0.18	3.4	20	1.0	0.7	0.00	7.5	8	0.0	7.5	0	54	64	114
2/14	0	0.09	0.06	0.15	3.4	20	1.5	0.5	0.00	7.0	12	0.5	7.4	0	52	64	111
3/2	0	0.10	0.03	0.12	3.1	19	1.5	0.8	0.00	8.0	12	0.5	7.4	0	50	60	108
3/23	0	...	0.09	0.19	3.4	17	1.5	0.8	0.00	7.0	12	...	7.3	0	48	56	98
4/7	0	...	0.06	0.20	2.4	15	1.5	1.1	0.00	5.0	11	0.6	7.4	0	40	48	89
4/28	7	...	0.08	0.16	1.9	9	1.5	1.5	0.00	3.0	12	1.3	7.4	0	22	30	55
7/7	18	...	...	0.10	3.4	22	1.5	0.4	0.00	6.0	11	0.4	7.7	0	66	70	125
7/21	22	...	...	0.02	4.4	23	1.5	0.5	0.00	6.0	2	0.6	7.9	0	70	76	128
9/2	14	...	...	0.18	3.4	18	1.0	0.4	0.00	4.5	10	0.8	7.8	0	54	60	106
10/22	6	...	...	0.03	2.4	15	1.0	0.3	0.00	4.5	4	0.8	7.7	0	40	48	85
11/23	0	...	...	0.00	2.9	15	1.5	0.5	0.00	5.5	6	1.3	7.6	0	42	50	89
12/14	0	...	...	0.07	2.9	13	1.0	0.5	0.00	6.0	8	0.5	7.5	0	34	44	79
1965																	
1/19	0	...	...	0.18	2.9	16	1.0	0.4	0.00	7.0	11	0.5	7.5	0	44	52	94
2/23	0	...	...	0.22	2.9	18	1.0	0.7	0.00	7.0	6	0.5	7.7	0	48	56	104
3/17	0	...	...	0.18	2.9	18	2.0	2.2	0.00	6.0	14	0.2	7.7	0	48	56	100
4/13	1	...	...	0.13	1.9	8	0.7	1.9	0.00	4.0	15	1.4	7.3	0	18	28	53
5/6	12	0.09	0.01	0.12	1.5	8	1.0	1.9	0.00	3.5	11	1.4	7.4	0	18	26	48
5/28	10	0.10	0.04	0.15	2.9	14	0.7	0.4	0.00	4.5	9	1.2	7.6	0	38	46	81
6/17	11	0.04	0.05	0.14	3.4	19	1.0	0.4	0.00	5.5	10	0.3	7.9	0	56	62	110
7/19	...	0.03	0.07	0.08	4.4	23	1.5	0.3	0.00	6.0	11	0.2	7.8	0	70	76	132
8/9	19	0.04	0.07	0.14	2.9	23	1.0	0.2	0.00	7.5	7	0.1	8.0	0	64	70	124
9/9	12	0.05	0.03	0.12	5.3	24	1.5	0.1	0.00	5.5	5	0.3	7.8	0	72	82	139
10/13	6	0.05	0.04	0.20	3.9	20	1.5	0.4	0.00	6.0	12	1.9	7.7	0	56	66	115
11/2	3	0.09	0.01	0.08	2.9	15	1.5	0.6	0.00	5.5	11	1.3	7.6	0	40	50	89
12/8	1	0.10	0.02	0.13	2.4	13	1.0	0.4	0.00	4.5	12	0.8	7.6	0	32	42	76

Table 6.--Water quality of the Big Garlic River, Marquette County, Mich., 1962-65

[Water samples were taken at County Road 550 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
8/23	...	0.15	...	0.20	4.9	18	...	0.1	0.00	5.0	18	0.2	7.6	0	58	66	109
12/13	...	0.20	...	0.30	3.9	14	...	0.8	0.00	7.0	18	0.6	7.2	0	40	50	88
1963																	
1/9	1	0.20	...	0.20	2.9	16	...	1.0	0.00	7.0	20	0.4	7.6	0	45	52	98
1/23	0	0.15	0.10	0.20	4.9	18	...	1.6	0.00	8.0	22	0.3	7.3	0	52	64	106
2/5	0	0.15	0.10	0.20	4.9	18	...	1.4	0.00	8.0	19	0.2	7.5	0	54	64	109
2/26	0	0.10	0.10	0.20	3.4	19	...	1.5	0.00	8.0	18	0.0	7.5	0	56	62	111
3/12	0	0.10	0.05	0.15	3.9	19	...	1.5	0.00	8.0	17	0.2	7.6	0	56	64	111
3/27	1	0.20	0.05	0.20	2.9	13	0.5	2.0	0.00	6.0	7	1.0	7.4	0	34	44	77
4/8	2	0.20	0.10	0.15	2.2	7	1.0	1.6	0.00	4.0	6	1.6	7.0	0	18	26	47
4/23	3	0.15	0.05	0.15	3.4	10	1.0	0.8	0.00	6.0	10	1.1	7.2	0	30	40	75
5/20	8	0.10	...	0.15	3.9	14	0.5	0.4	0.00	5.0	5	0.6	7.3	0	42	52	85
6/4	16	0.13	0.10	0.20	3.4	14	1.0	0.4	0.00	5.0	5	0.9	7.3	0	40	48	84
6/27	17	0.17	0.07	0.20	3.4	16	0.5	0.9	0.00	7.0	4	0.3	7.3	0	48	54	91
7/10	14	0.11	0.07	0.20	3.9	18	0.5	0.9	0.00	7.0	6	0.5	7.5	0	56	62	110
7/26	19	0.14	0.04	0.20	3.9	20	1.0	0.5	0.00	7.0	3	0.5	7.7	0	62	66	120
8/20	13	0.13	0.09	0.22	3.9	18	1.0	0.7	0.00	8.5	7	0.7	7.6	0	54	62	108
9/19	14	0.14	0.05	0.21	3.1	20	1.0	0.6	0.00	7.5	5	0.6	7.6	0	60	63	114
10/3	11	0.12	0.04	0.20	3.9	20	1.0	0.2	0.00	6.0	4	0.9	7.4	0	60	66	124
10/16	11	0.08	0.08	0.15	3.6	20	1.0	0.2	0.00	8.5	5	0.8	7.5	0	59	64	116
11/14	3	0.17	0.05	0.25	2.9	12	1.5	1.5	0.00	5.0	12	1.5	7.2	0	30	42	74
12/6	0	0.07	0.06	0.40	3.4	18	1.0	1.7	0.00	7.0	11	0.4	7.5	0	50	58	104
1964																	
1/8	0	0.06	0.05	0.15	3.4	17	1.0	1.6	0.00	8.0	12	0.4	7.4	0	48	56	98
1/27	0	0.08	0.02	0.09	2.9	18	1.0	1.5	0.00	8.0	6	0.0	7.4	0	50	56	102
2/14	0	0.12	0.05	0.18	4.4	17	1.0	1.0	0.00	7.0	10	0.3	7.2	0	50	60	100
3/2	0	0.06	0.08	0.21	2.9	17	1.0	1.8	0.00	9.0	6	0.5	7.1	0	48	54	98
3/23	0	...	0.07	0.23	3.9	17	1.0	1.1	0.00	8.5	6	0.5	7.1	0	49	58	101
4/7	0	...	0.10	0.27	2.4	14	1.5	1.6	0.00	7.0	5	0.3	7.3	0	40	46	89
4/28	7	...	0.06	0.20	1.5	8	1.5	0.9	0.00	4.0	9	1.4	7.3	0	20	26	53
7/7	17	...	...	0.17	2.4	20	1.0	1.0	0.00	7.0	5	0.7	7.8	0	56	60	109
7/21	21	...	...	0.29	2.9	20	1.0	0.9	0.00	6.0	4	0.8	7.8	0	60	62	117
9/2	13	...	...	0.25	3.9	17	1.0	0.8	0.00	6.0	5	0.9	7.9	0	50	58	97
10/22	6	...	...	0.09	3.4	14	1.0	0.5	0.00	5.0	6	0.8	7.6	0	40	48	84
11/23	0	...	...	0.09	5.8	15	1.0	1.1	0.00	8.0	7	0.9	7.6	0	45	62	96
12/14	0	...	...	0.05	2.9	14	1.0	1.1	0.00	7.0	5	0.5	7.5	0	40	46	85
1965																	
1/19	0	...	...	0.07	2.9	16	1.0	0.7	0.00	8.5	7	0.1	7.5	0	46	52	96
2/24	0	...	...	0.23	3.4	17	1.0	1.7	0.00	9.5	10	0.2	7.6	0	50	56	103
3/17	0	...	...	0.14	3.4	18	1.5	2.9	0.00	8.5	12	0.2	7.7	0	50	58	101
4/13	2	...	...	0.17	2.2	8	1.0	1.5	0.00	6.0	11	1.3	7.3	0	20	30	55

Table 6.--Continued

Date	Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.³ at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
5/6	10	0.12	0.01	0.12	1.5	6	1.0	1.7	0.00	3.0	13	1.6	7.1	0	14	20	40
5/28	9	0.16	0.05	0.28	2.9	12	0.7	0.6	0.00	6.0	6	1.2	7.5	0	36	42	77
6/17	10	0.05	0.07	0.15	3.4	16	0.5	0.7	0.00	7.0	8	0.4	7.9	0	48	54	96
7/19	...	0.02	0.07	0.15	3.9	19	0.5	0.8	0.00	9.5	10	0.4	7.8	0	56	64	110
8/9	18	0.05	0.06	0.22	3.9	16	1.0	0.7	0.00	8.0	12	0.8	7.9	0	46	56	96
9/9	12	0.02	0.06	0.21	3.4	19	0.5	0.6	0.00	9.0	8	0.2	7.8	0	56	62	114
10/13	6	0.07	0.06	0.24	3.4	16	0.5	0.5	0.00	7.5	12	1.1	7.7	0	46	54	97
11/2	3	0.11	0.05	0.04	2.9	13	1.5	0.8	0.00	7.5	9	1.0	7.5	0	34	44	79
12/8	1	0.09	0.07	0.19	2.4	14	1.0	0.6	0.00	8.5	14	0.4	7.8	0	38	44	83
1964																	
9/2 1/	13	...	...	0.30	3.9	18	2.5	0.6	0.00	6.0	10	0.9	7.8	0	56	62	115
9/2 2/	11	...	...	0.06	4.4	29	0.5	0.7	0.00	9.0	8	0.3	8.0	0	88	90	158

1/ Wilson Creek, tributary to main stem. Water sample was taken above junction with Sawmill Creek.
2/ Sawmill Creek, tributary to main stem. Water sample was taken at County Road 550 bridge.

Table 7.--Water quality of the Ford River, Delta County, Mich., 1962-65

[Water samples were taken at Highway M-95 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^{-}	NO_3^{-}	NO_2^{-}	SiO_2	$SO_4^{=}$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.3 at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/10	0	0.10	0.10	0.15	18.0	34	...	1.3	0.00	8.0	22	0.8	7.9	0	141	160	269
1963																	
1/7	0	0.10	0.10	0.15	24.0	45	...	1.6	0.00	11.0	23	0.6	7.9	0	194	210	346
1/21	0	0.05	0.10	0.10	26.0	47	...	2.2	0.00	11.0	25	0.4	7.8	0	212	226	374
2/4	0	0.05	0.10	0.15	26.0	47	...	2.3	0.00	12.0	27	0.2	7.7	0	210	224	374
2/25	0	0.05	0.10	0.15	25.0	50	...	2.2	0.00	11.0	25	0.2	8.1	0	210	226	374
3/11	0	0.10	0.05	0.15	26.0	47	...	1.9	0.00	11.0	20	0.5	7.9	0	208	224	355
3/25	0	0.15	0.02	0.20	16.0	31	...	1.7	0.00	6.0	21	1.0	7.7	0	128	146	255
4/14	4	...	...	...	15.0	31	...	...	...	...	...	...	8.0	0	120	138	232
4/28	8	...	...	...	12.0	29	4.0	...	...	...	17	...	7.5	0	94	120	192
5/12	7	...	...	...	9.0	19	2.5	...	...	...	15	...	7.9	0	58	85	130
6/9	17	...	...	...	13.0	26	3.0	0.9	0.00	4.0	2	2.0	7.7	0	98	118	183
6/30	27	...	...	...	18.0	40	4.0	...	...	5.0	11	...	8.0	0	152	176	283
7/14	19	...	...	...	25.0	49	3.5	...	...	9.0	16	...	8.3	0	208	226	365
7/28	...	...	0.05	0.16	25.0	48	3.5	...	...	8.0	13	1.2	8.3	4	214	224	365
8/12	16	0.10	0.06	0.22	26.0	46	3.5	0.7	0.00	8.0	13	1.1	8.1	0	206	220	350
9/3	13	...	0.08	0.23	25.0	50	7.0	...	...	10.0	24	...	8.2	0	200	226	357
9/22	11	...	0.06	0.25	26.0	48	8.0	...	...	10.0	14	...	8.1	0	210	228	365
10/6	14	...	0.06	0.20	26.0	47	5.0	...	...	9.0	22	1.4	8.0	0	206	224	370
11/12	3	0.28	0.10	0.60	23.0	48	5.5	1.1	0.00	7.0	20	3.6	7.5	0	204	216	360
12/2	1	0.12	0.05	0.22	25.0	45	5.0	1.6	0.00	8.0	34	0.9	7.7	0	188	216	360
1964																	
1/6	1	0.10	0.08	0.23	27.0	46	3.5	1.8	0.00	11.0	23	0.4	7.8	0	206	228	374
2/3	0	0.06	0.09	0.18	24.0	48	3.5	1.7	0.00	8.0	24	0.4	7.6	0	198	220	360
3/9	1	0.05	0.03	0.07	24.0	47	4.5	2.3	0.00	11.0	21	0.5	7.7	0	194	216	360
3/30	1	...	0.07	0.08	25.0	48	4.5	1.3	0.00	12.0	26	0.9	7.8	0	202	222	374
4/16	1	...	0.04	0.17	12.0	25	6.5	4.1	0.00	3.5	35	2.0	7.6	0	74	112	200
6/9	18	...	0.07	0.24	13.0	36	4.0	1.3	0.01	3.5	28	1.8	7.9	0	116	142	245
6/12	11	...	...	0.21	12.0	27	4.0	...	...	3.0	28	2.6	7.6	0	84	116	188
7/6	17	...	...	0.24	14.0	33	4.5	...	...	3.5	15	2.8	7.9	0	118	140	230
7/27	18	...	...	0.17	15.0	35	4.0	1.1	0.00	4.0	19	2.2	7.8	0	124	148	240
8/23	14	...	...	0.20	17.0	37	7.0	1.0	0.00	5.0	9	2.1	8.2	0	144	162	267
9/28	7	...	...	0.04	12.0	26	4.0	1.1	0.00	3.0	8	3.1	7.6	0	94	114	184
11/11	8	...	...	0.15	13.0	30	4.0	1.1	0.00	5.0	13	1.5	7.8	0	108	130	221
12/14	1	...	...	0.16	18.0	40	4.5	1.2	0.00	10.0	18	0.8	7.9	0	156	174	290
1965																	
1/25	1	...	...	0.21	22.0	42	5.0	1.3	0.01	11.0	20	0.7	7.9	0	178	194	326
2/22	0	...	...	0.17	24.0	43	5.0	1.8	0.00	11.0	15	1.2	8.0	0	190	208	346
3/15	1	...	...	0.27	23.0	45	6.0	1.3	0.01	10.0	19	0.1	8.0	0	192	208	346
4/19	2	...	...	0.19	7.8	18	2.0	2.4	0.00	4.0	22	2.1	7.5	0	58	78	137

Tsble 7.--Continued

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.3 at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
5/23	14	...	0.02	0.17	10.0	22	2.0	1.1	0.00	2.5	2	2.4	7.6	0	76	98	150
6/20	21	0.07	0.04	0.16	17.0	39	5.0	1.0	0.00	6.0	14	1.1	8.2	0	154	170	280
7/18	18	0.05	0.04	0.23	24.0	47	3.5	1.0	0.00	7.5	17	1.2	8.3	0	202	218	360
8/8	18	0.04	0.06	0.19	23.0	47	4.0	0.8	0.01	9.0	19	1.1	8.2	0	196	214	350
9/7	13	0.01	0.02	0.06	24.0	49	8.0	0.2	0.00	0.5	28	0.9	8.3	2	196	220	355
10/10	10	0.04	0.05	0.13	14.0	35	5.0	0.9	0.00	5.0	34	2.0	7.9	0	108	144	238
10/31	6	0.07	0.06	0.16	18.0	37	4.0	0.8	0.00	9.5	28	1.1	8.1	0	138	166	276
12/12	2	0.03	0.03	0.08	15.0	28	5.5	1.9	0.00	8.0	30	0.8	7.9	0	98	130	226
1963 1/																	
1/24	0	0.05	0.10	0.15	23.0	54	...	0.8	0.00	10.0	29	0.6	7.7	0	208	228	374
2/27	0	0.08	0.10	0.15	23.0	52	...	0.8	0.00	10.0	24	0.8	7.7	0	202	224	365
3/28	0	0.15	0.10	0.15	13.0	33	2.5	2.1	0.00	3.0	17	0.8	7.6	0	120	136	228
1964 1/																	
3/10	0	0.04	0.04	0.20	19.0	50	2.5	0.9	0.00	7.0	27	0.7	7.8	0	186	204	336
6/12	16	...	...	0.21	16.0	39	2.0	...	...	3.0	24	1.6	8.1	0	138	166	269
1964 2/																	
3/10	0	0.04	0.09	0.30	21.0	41	2.0	0.4	0.00	11.0	23	0.4	7.9	0	172	188	312
6/12	13	...	...	0.28	15.0	29	2.0	...	...	5.0	30	1.8	7.7	0	98	132	211
1964 3/																	
3/10	0	0.03	0.07	0.27	21.0	41	2.0	0.9	0.00	10.0	23	0.6	7.7	0	172	188	312
6/12	16	...	...	0.28	15.0	36	2.0	...	...	3.5	24	1.5	7.9	0	128	152	250

1/ Water samples were taken 1/4 mile above mouth.
2/ Water samples were taken at County Road 581 bridge.
3/ Water samples were taken at bridge, T. 41 N., R. 24 W., sec. 19.

p.p.m.; calcium, 18 to 50 p.p.m.; chlorides, 2.0 to 8.0 p.p.m.; pH, 7.5 to 8.3; total alkalinity, 58 to 214 p.p.m.; total hardness, 78 to 228 p.p.m.; and conductivity, 130 to 374 micromhos. Water temperature varied from 0° to 27° C. (32° to 80° F.).

Water quality data from the stations at State Highway M-95 bridge and the mouth were similar (table 7). Values for data from the two intermediate stations were slightly lower.

PENSAUKEE RIVER, OCONTO COUNTY, WIS.

The Pensaukee River, a tributary to southern Green Bay, Lake Michigan, was sampled at U.S. Highway 141 bridge in Oconto County, Wis. The main stream is 48 km. (30 miles) long and has 121 km. (75 miles) of tributary streams and a drainage area of 453 $km.^2$ (175 sq. miles). The North Branch of the Pensaukee River is the main tributary and, except during the spring runoff, contributes most of the water. The flow ranged from 0.3 to 0.9 $m.^3$/sec. (10 to 30 c.f.s.) but flows were higher during the spring runoff and heavy rains. The water was clear, slightly alkaline, and moderately colored. Turbidity and color increased during high water.

Water quality data were collected from December 1962 through December 1965 (table 8). Aluminum, copper, and iron varied little throughout the year. The lowest concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were during the spring runoff. From May through August, when flows remained nearly constant or slowly receded, these values dropped and reached a low in July and August, and then increased to their highest in the winter. Chlorides were higher during low flows and lower at high flows. Concentrations of nitrate, silica, and sulfates were lowest in the summer. Nitrite was found in many samples. Concentrations of tanninlike and ligninlike compounds were highest during the spring runoff and when flows increased and lowest during low flows. The pH values were lowest in the winter and during the spring runoff and highest in the summer and fall. Phenolphthalein alkalinity was found in many samples from April through November. The ranges for values of selected measurements were: magnesium, 5.3 to 35.0 p.p.m.; calcium, 20 to 86 p.p.m.; chloride, 4.5 to 14.0 p.p.m.; pH, 7.5 to 9.0; phenolphthalein alkalinity, 0 to 18 p.p.m.; total alkalinity, 60 to 302 p.p.m.; total hardness, 72 to 360 p.p.m.; and conductivity, 149 to 576 micromhos. Water temperature varied from 0° to 33° C. (32° to 91° F.).

AHNAPEE RIVER, KEWAUNEE COUNTY, WIS.

The Ahnapee River, a tributary to Lake Michigan, was sampled at County Road J bridge in Door County, Wis. The main stream is 21 km. (13 miles) long and has 85 km. (53 miles) of tributary streams and a drainage area of 285 $km.^2$ (110 sq. miles). The flow usually ranged from 0.2 to 0.4 $m.^3$/sec. (6 to 15 c.f.s.) but was higher during the spring runoff and heavy rains. The water was clear, slightly alkaline, and moderately colored. Turbidity and color increased when flow increased.

Water quality data were collected from December 1962 through December 1965 (table 9). Aluminum, copper, and iron varied little throughout the year. Concentrations of magnesium, calcium, total alkalinity, and total hardness, and conductivity readings were low during the spring runoff. From May through September as flows remained nearly constant or slowly receded, these values dropped to low levels in August and September, and then increased to their highest in winter. The values were higher when flow increased in rainy weather. Chlorides were high during low flows and lower when flows increased. Concentrations of nitrate, silica, and sulfates were lowest in the summer. Nitrite was present in most samples and was highest in the winter. Concentrations of tanninlike and ligninlike compounds were high during the spring runoff and when flow increased. The pH values were highest in the summer and fall and were low in the winter and during the spring runoff. Phenolphthalein alkalinity was found in many samples from April to November. The ranges for values of selected measurements were: magnesium, 20.0 to 45.0 p.p.m.; calcium, 29 to 89 p.p.m.; chloride, 5.5 to 13.0 p.p.m.; pH, 7.8 to 8.8; phenolphthalein alkalinity, 0 to 18 p.p.m.; total alkalinity, 156 to 354 p.p.m.; total hardness, 192 to 400 p.p.m.; and conductivity, 317 to 614 micromhos. Water temperature varied from 0° to 24° C. (32° to 76° F.).

OTHER STREAMS TRIBUTARY TO LAKES SUPERIOR AND MICHIGAN

Water quality measurements for other streams tributary to Lake Superior (table 10) and Lake Michigan (table 11) were few and scattered but are sufficient to provide data on some general characteristics of the streams and lake drainages.

Traces of aluminum, copper, and iron and varying amounts of nitrate, silica, sulfate, and tanninlike and ligninlike compounds were found at most stations.

Table 8.--Water quality of the Pensaukee River, Oconto County, Wis., 1962-65

[Water samples were taken at U.S. Highway 141 bridge.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.3 at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/10	0	0.10	0.10	0.15	35.0	86	...	1.5	0.00	5.0	80	2.1	8.2	0	294	360	557
1963																	
1/7	0	0.02	0.10	0.15	27.0	69	...	4.5	0.01	10.0	35	1.1	8.0	0	249	282	461
1/21	0	0.05	0.10	0.10	33.0	79	...	4.6	0.03	13.0	40	0.9	7.7	0	296	332	557
2/4	0	0.05	0.10	0.10	35.0	78	...	4.2	0.02	14.0	47	0.8	7.6	0	302	340	557
2/25	0	0.05	0.10	0.10	32.0	76	...	3.8	0.01	13.0	45	0.8	7.7	0	284	320	576
3/11	0	0.05	0.10	0.15	29.0	64	...	4.0	0.01	12.0	37	0.9	7.7	0	246	280	461
3/25	1	0.10	0.02	0.15	5.3	20	...	1.4	0.02	2.0	15	3.6	7.6	0	60	72	149
4/14	12	...	...	...	23.0	59	...	...	...	...	...	...	...	6	202	244	386
4/28	16	...	...	...	30.0	66	10.0	...	...	...	52	...	8.3	6	214	288	427
5/12	11	...	...	...	24.0	62	7.5	...	...	...	64	...	8.3	5	194	254	403
6/9	23	...	...	...	23.0	53	6.5	0.4	0.00	7.0	21	1.5	8.1	0	206	228	365
6/30	33	...	...	...	25.0	42	6.5	...	...	9.0	23	...	8.7	14	182	208	374
7/14	27	...	...	...	24.0	38	11.0	...	...	5.0	16	...	8.9	16	172	194	329
7/28	...	...	0.05	0.09	26.0	33	7.0	...	...	5.0	15	0.9	9.0	18	172	188	300
8/12	21	0.06	0.05	0.12	27.0	34	13.0	0.2	0.00	3.0	16	0.7	8.1	0	174	194	331
9/3	17	...	0.08	0.12	25.0	42	8.5	...	...	1.0	23	...	8.2	0	184	208	343
9/22	16	...	0.06	0.09	26.0	45	14.0	...	...	0.5	26	...	8.8	8	193	220	360
10/6	21	...	0.07	0.11	28.0	46	7.5	...	...	0.5	30	1.0	8.5	12	208	230	376
11/12	4	0.05	0.07	0.09	29.0	58	8.0	0.1	0.00	3.0	34	1.0	8.3	4	236	262	432
12/2	1	0.05	0.08	0.14	34.0	73	14.0	1.4	0.01	6.0	54	1.2	8.3	6	276	322	557
1964																	
1/6	1	0.01	0.03	0.03	33.0	68	6.5	3.5	0.00	12.0	33	0.8	7.7	0	268	304	499
2/3	0	0.09	0.05	0.19	20.0	59	9.5	2.0	0.02	5.0	36	2.7	7.5	0	200	236	413
3/9	1	0.08	0.04	0.16	7.3	59	8.5	3.5	0.01	5.0	32	2.5	7.7	0	148	178	322
3/30	1	...	0.05	0.16	24.0	57	7.0	1.0	0.00	6.0	42	1.3	8.0	0	204	242	413
4/16	9	...	0.05	0.26	22.0	55	12.0	1.0	0.00	3.5	55	1.9	8.1	0	166	230	398
6/9	26	...	0.08	0.21	26.0	56	8.0	0.6	0.00	1.5	33	1.5	8.5	7	218	248	403
7/6	19	...	...	0.05	25.0	38	7.0	...	...	6.0	20	1.1	8.3	0	182	200	336
7/27	23	...	...	0.12	18.0	40	4.5	0.4	0.00	4.0	25	1.2	8.2	0	154	176	296
8/23	20	...	...	0.05	24.0	39	11.0	0.3	0.00	1.5	24	0.6	8.8	12	178	198	331
9/28	9	...	...	0.12	28.0	67	12.0	0.4	0.00	4.0	51	2.1	8.3	0	230	284	480
11/11	12	...	...	0.05	30.0	66	13.0	0.3	0.00	2.0	52	1.4	8.4	6	234	286	480
12/14	1	...	...	0.09	30.0	70	10.0	2.8	0.01	8.0	44	1.0	8.1	0	258	298	499
1965																	
1/25	1	...	...	0.18	29.0	70	11.0	2.0	0.05	12.0	35	1.6	7.7	0	268	294	509
2/22	0	...	...	0.25	23.0	64	12.0	1.8	0.02	9.0	38	3.0	7.6	0	228	254	461
3/15	1	...	...	0.19	14.0	38	8.0	1.6	0.01	3.0	32	2.8	7.8	0	128	154	259
4/19	6	...	...	0.22	15.0	46	6.5	3.5	0.02	4.5	48	2.2	8.0	0	134	176	302
5/23	17	...	0.06	0.02	24.0	68	7.5	1.0	0.00	1.0	50	2.8	8.3	0	224	270	413
6/20	26	0.08	0.05	0.11	30.0	42	8.0	0.8	0.01	0.5	30	1.2	8.9	6	200	230	355
7/18	27	0.06	0.02	0.11	20.0	46	6.0	0.3	0.00	2.5	37	1.3	9.0	14	166	196	317
8/8	21	0.03	0.03	0.13	23.0	40	7.5	0.2	0.00	3.0	24	1.0	8.3	0	174	194	293
9/7	17	0.02	0.06	0.24	26.0	47	8.5	1.0	0.01	11.0	16	0.9	8.5	4	198	224	379
10/10	14	0.05	0.04	0.25	21.0	75	10.0	0.8	0.00	5.0	56	2.4	8.4	4	216	274	446
10/31	8	0.04	0.07	0.14	28.0	72	8.5	0.6	0.00	1.5	46	2.2	8.6	8	238	294	461
12/12	3	0.02	0.06	0.14	18.0	47	7.0	2.4	0.01	4.5	37	0.9	8.1	0	154	194	331

Table 9.--Water quality of the Ahnapee River, Kewaunee County, Wis., 1962-65

[Water samples were taken at County Road J bridge in Door County, Wis.]

Date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^{=}$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.^{3} at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
1962																	
12/10	0	0.05	0.10	0.10	38.0	72	...	4.7	0.00	2.0	35	1.2	8.3	0	302	338	480
1963																	
1/7	0	...	0.10	0.15	43.0	89	...	6.4	0.01	6.0	42	1.6	8.2	0	354	400	614
1/21	0	0.05	0.10	0.10	38.0	84	...	5.6	0.03	8.0	37	1.1	7.9	0	332	368	595
2/4	0	0.05	0.10	0.20	40.0	83	...	6.0	0.03	9.0	42	1.1	7.9	0	340	374	595
2/25	0	0.05	0.05	0.15	39.0	82	...	5.4	0.04	10.0	38	1.0	7.9	0	332	366	576
3/11	0	0.05	0.10	0.15	45.0	69	...	5.8	0.03	10.0	35	1.3	7.8	0	334	368	595
3/25	1	0.05	0.05	0.15	30.0	62	...	4.4	0.03	7.0	33	1.8	7.8	0	240	278	461
4/14	7	...	...	...	29.0	60	...	...	...	...	...	...	8.4	8	228	270	413
4/28	13	...	...	...	35.0	56	7.5	...	...	...	38	...	8.4	6	266	286	446
5/12	12	...	...	...	36.0	54	5.5	...	...	...	25	...	8.3	5	248	282	437
6/9	22	...	...	...	31.0	56	6.0	0.5	0.00	3.0	17	1.5	8.0	0	242	266	422
6/30	22	...	...	...	34.0	50	7.5	...	...	2.0	24	...	8.0	0	238	264	422
7/14	22	...	...	...	32.0	50	8.0	...	...	4.0	12	...	8.3	6	238	256	418
7/28	...	...	0.05	0.15	33.0	42	8.0	...	...	7.0	9	1.5	8.5	10	228	242	384
8/12	19	0.08	0.08	0.18	34.0	46	10.0	1.4	0.01	8.0	15	1.5	8.0	0	230	252	403
9/3	18	...	0.08	0.20	27.0	42	11.0	...	...	4.0	20	...	8.1	0	192	218	355
9/22	13	...	0.07	0.12	30.0	42	13.0	...	...	2.0	18	...	8.3	0	208	230	379
10/6	15	...	0.06	0.10	32.0	38	8.5	...	...	1.0	24	0.9	8.3	4	206	228	338
11/12	4	0.04	0.10	0.14	36.0	50	9.0	0.4	0.00	2.0	30	1.1	8.3	2	248	274	442
12/2	1	0.07	0.06	0.12	37.0	55	9.0	0.7	0.00	1.0	30	1.0	8.1	0	264	292	475
1964																	
1/6	2	0.05	0.06	0.10	44.0	66	9.5	1.2	0.01	2.5	31	1.2	8.1	0	312	346	552
2/3	1	0.05	0.05	0.15	36.0	66	7.0	3.5	0.02	4.0	28	1.1	7.9	0	282	316	490
3/9	3	0.06	0.09	0.11	35.0	66	8.0	4.3	0.01	1.5	38	1.2	8.1	0	272	312	499
3/30	1	...	0.09	0.10	24.0	52	6.5	1.9	0.02	2.0	49	1.3	7.9	0	180	228	394
4/16	9	...	0.08	0.17	25.0	53	8.0	1.8	0.01	1.0	67	1.3	8.2	0	162	234	382
6/9	23	...	0.09	0.13	31.0	41	8.0	0.8	0.01	0.5	42	1.2	8.8	18	184	228	365
7/6	18	...	...	0.12	31.0	29	9.0	...	...	2.0	36	1.2	8.7	10	166	200	322
7/27	21	...	...	0.00	29.0	31	9.0	0.6	0.01	2.0	21	1.2	8.4	3	170	196	328
8/23	18	...	...	0.03	29.0	30	13.0	0.3	0.00	2.5	16	0.9	8.5	6	174	192	317
9/28	10	...	...	0.13	29.0	37	8.0	0.7	0.00	1.0	26	1.3	8.3	0	184	210	355
11/11	12	...	...	0.00	34.0	47	8.5	0.3	0.00	1.5	33	1.0	8.3	2	228	258	432
12/14	1	...	...	0.17	41.0	66	10.0	0.5	0.01	3.0	36	1.1	8.1	0	298	330	528
1965																	
1/25	1	...	...	0.13	36.0	74	9.5	4.0	0.04	3.0	41	2.3	7.9	0	294	332	538
2/22	0	...	...	0.19	27.0	63	9.0	3.8	0.05	5.5	37	2.4	7.8	0	234	268	456
3/15	1	...	...	0.14	22.0	49	6.0	3.0	0.02	3.0	55	1.6	7.9	0	156	214	355
4/19	8	...	...	0.08	20.0	54	6.0	5.4	0.02	3.5	54	1.7	8.1	0	172	222	370
5/23	17	...	0.05	0.00	28.0	63	6.0	1.4	0.01	0.0	45	2.6	8.6	8	232	274	422
6/20	24	0.02	0.01	0.02	25.0	57	7.0	0.7	0.00	1.5	28	1.3	8.6	3	220	246	389
7/18	21	0.02	0.03	0.15	30.0	38	7.5	0.7	0.01	3.0	22	1.4	8.3	0	194	220	355
8/8	21	0.03	0.05	0.11	31.0	42	8.0	0.6	0.01	2.0	18	1.3	8.0	0	208	230	374
9/7	17	0.05	0.06	0.18	28.0	43	7.5	0.8	0.01	3.0	18	1.0	8.1	0	202	224	370
10/10	11	0.04	0.04	0.16	29.0	78	8.5	3.0	0.03	2.5	51	2.1	8.0	0	256	316	490
10/31	8	0.07	0.02	0.09	37.0	78	9.0	3.1	0.01	0.5	38	2.2	8.4	0	292	346	538
12/12	3	0.02	0.07	0.03	26.0	59	7.5	5.0	0.01	3.5	36	0.9	8.1	0	212	256	427

Table 10.--Water quality of streams tributary to Lake Superior, 1962-65

[Stream numbers correspond to those assigned to streams in the text and figure 1. Letters in parentheses indicate more than one location on a stream was sampled.]

County, state, stream number,	and date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Chippewa County, Mich.																		
1	1/15/64	0	0.42	0.02	0.65	18.0	52	19.0	3.1	0.00	11.0	63	4.9	7.5	0	142	204	379
2	7/21/63	17	...	0.06	0.07	3.9	10	0.5	...	...	7.0	6	...	7.5	0	32	42	67
	1/14/64	1	0.06	0.04	0.05	2.9	11	0.5	0.4	0.00	9.5	4	0.4	7.4	0	36	40	74
3	7/21/63	13	...	0.07	0.38	3.9	14	0.3	...	...	6.0	8	...	7.6	0	48	52	90
	1/14/64	2	0.18	0.08	0.29	3.4	14	0.5	0.6	0.00	10.0	13	0.6	7.5	0	44	50	92
4	1/14/64	1	0.10	0.07	0.03	4.9	16	0.5	2.5	0.00	8.0	9	0.2	7.7	0	50	60	106
5	7/21/63	15	...	0.06	0.05	7.3	22	0.5	...	...	7.0	9	...	7.9	0	82	86	151
	1/14/64	3	0.05	0.06	0.09	7.3	21	0.5	2.8	0.00	11.0	10	0.2	7.8	0	74	82	145
6	7/21/63	14	...	0.08	0.10	8.3	24	0.5	...	...	6.5	6	...	7.9	0	88	94	162
	1/14/64	2	0.05	0.09	0.05	7.3	22	0.5	1.2	0.00	9.5	12	0.1	7.6	0	76	84	148
7	1/14/64	1	0.09	0.07	0.08	6.3	18	0.5	2.8	0.00	8.0	12	0.4	7.8	0	62	72	132
8	7/21/63	14	...	0.03	0.16	3.4	14	2.0	...	...	4.0	13	...	7.8	0	40	50	91
	1/15/64	0	0.10	0.00	0.15	5.3	14	1.5	1.6	0.00	6.0	14	0.7	7.4	0	36	56	93
9 (a)	1/15/64	0	0.17	0.09	0.38	6.3	25	2.0	1.1	0.00	5.0	24	1.1	7.6	0	66	88	152
	7/6/64	23	...	...	0.32	6.8	27	1.5	...	...	3.0	25	1.3	8.1	0	80	96	169
	7/14/64	21	...	...	0.26	5.8	26	...	...	...	3.5	19	1.2	7.9	0	76	88	156
9 (b)	1/15/64	0	0.05	0.06	0.13	5.8	24	1.5	0.7	0.00	8.0	16	0.8	7.3	0	72	84	146
	7/14/64	21	...	...	0.23	6.8	30	...	...	...	3.5	19	1.2	7.9	0	90	102	177
10	1/15/64	0	0.14	0.04	0.80	3.4	10	1.0	0.7	0.00	4.0	8	1.4	7.1	0	30	40	66
	8/19/65	17	0.23	0.03	2.10	2.9	10	1.0	0.9	0.00	1.5	5	2.8	7.5	0	32	38	60
Luce County, Mich.																		
11	11/18/63	6	0.18	0.07	0.80	4.4	15	1.0	0.6	0.00	5.0	7	1.2	7.4	0	46	56	91
	7/28/65	13	0.17	0.07	1.75	7.3	19	1.0	0.6	0.00	4.5	2	2.0	7.4	0	62	78	111
12 (a)	11/18/63	8	0.25	0.04	0.85	4.4	18	1.5	1.0	0.00	4.0	10	1.4	7.5	0	52	62	107
	7/21/65	14	0.13	0.04	0.04	4.4	22	0.5	0.7	0.00	4.5	3	1.4	7.9	0	60	74	113

Table 10.--Continued

County, state, stream number, and date		Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
12 (b)	11/18/63	6	0.15	0.06	0.65	4.4	17	1.0	0.7	0.00	6.0	6	1.0	7.5	0	52	60	104
	7/21/65	11	0.12	0.05	0.14	5.3	18	1.0	0.8	0.00	4.5	5	1.2	7.8	0	62	68	113
12 (c)	11/18/63	6	0.22	0.07	0.80	4.9	19	1.0	1.0	0.00	5.0	8	1.3	7.6	0	60	68	116
	7/21/65	13	0.11	0.04	0.94	5.3	22	1.0	0.8	0.00	5.0	5	1.4	8.0	0	66	76	122
12 (d)	7/21/65	14	0.29	0.05	1.90	3.4	19	0.5	1.1	0.00	1.0	2	3.5	7.8	0	60	62	102
12 (e)	7/21/65	12	0.06	0.06	0.72	5.8	22	0.5	0.6	0.00	6.0	9	0.7	7.9	0	72	80	126
12 (f)	7/21/65	13	0.30	0.07	2.30	5.3	16	1.0	1.3	0.00	0.5	2	4.5	7.7	0	52	62	94
13	9/9/63	...	...	0.10	0.24	5.3	21	1.0	...	...	2.0	3	0.8	8.2	0	69	74	125
	11/20/63	6	0.06	0.05	0.15	5.8	21	1.0	0.1	0.00	3.5	4	0.3	7.6	0	72	76	133
Alger County, Mich.																		
14 (a)	9/9/63	14	...	0.07	0.33	5.3	17	2.0	...	...	4.5	7	1.4	7.7	0	53	64	112
14 (b)	9/9/63	14	...	0.08	0.23	4.4	18	2.0	...	...	6.0	6	1.2	7.7	0	58	64	111
	11/20/63	4	0.15	0.03	0.21	4.4	17	1.5	0.8	0.00	5.0	9	1.4	7.6	0	52	60	108
	8/19/65	14	0.13	0.03	0.40	4.9	17	1.0	0.9	0.00	4.5	1	2.1	7.8	0	54	62	106
14 (c)	9/9/63	14	...	0.05	0.10	5.3	23	1.0	...	...	8.5	4	0.6	7.8	0	75	80	140
	11/20/63	6	0.04	0.06	0.10	5.3	23	0.5	0.5	0.00	9.0	4	0.1	7.7	0	76	80	140
	8/19/65	10	0.04	0.06	0.11	5.3	23	0.5	0.5	0.00	8.5	12	0.1	8.0	0	74	80	138
15	11/26/63	3	0.15	0.05	0.31	4.4	14	1.5	1.5	0.00	4.0	13	1.7	7.5	0	40	54	93
16	11/26/63	4	0.18	0.07	0.38	4.9	22	1.0	0.5	0.00	5.0	12	1.0	7.6	0	64	74	128
17	7/15/63	16	...	...	...	5.3	24	0.2	...	...	7.0	9	...	8.7	4	68	82	132
	11/21/63	6	0.03	0.08	0.06	4.4	23	0.5	1.7	0.00	7.0	11	0.1	7.6	0	68	76	135
18	7/16/63	15	...	0.06	0.10	14.0	30	0.5	...	...	4.0	10	...	8.3	0	120	132	211
	11/21/63	6	0.04	0.06	0.10	15.0	30	1.0	0.7	0.00	4.0	25	0.5	7.9	0	116	138	230
19	11/21/63	6	0.11	0.05	0.17	16.0	32	2.0	1.2	0.00	4.0	23	0.8	7.9	0	128	148	246
20	1/10/63	2	0.05	0.10	0.10	5.3	26	...	2.5	0.00	8.0	25	0.2	7.8	0	73	86	154
	2/7/63	2	0.05	0.10	0.10	5.8	24	...	1.2	0.00	8.0	21	0.1	7.9	0	74	84	154
	3/6/63	2	0.10	0.10	0.05	6.8	25	...	2.3	0.00	8.0	14	0.1	7.8	0	74	90	154
	4/9/63	3	0.15	0.10	0.15	4.4	21	2.5	1.9	0.00	5.0	15	1.1	7.3	0	58	70	128
	1/16/64	4	0.08	0.10	0.14	5.3	25	2.0	2.0	0.00	8.5	15	0.1	7.8	0	74	84	154
	5/17/65	11	...	...	...	5.8	21	2.0	...	...	...	...	...	7.4	0	58	76	139

Table 10.--Continued

County, state, stream number, and date	Temper- ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol- phthalein alkalinity	Total alka- linity	Total hard- ness	Conductivity (micromhos/cm.^{3} at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
21 1/16/64	2	0.02	0.05	0.14	7.3	23	2.0	1.2	0.00	8.0	20	0.4	7.6	0	72	88	161
4/27/64	...	...	0.04	0.30	4.9	16	2.5	0.8	0.00	3.0	22	1.8	7.3	0	46	60	110
9/20/65	12	0.07	0.04	0.23	6.8	21	2.0	0.7	0.00	5.5	19	1.3	7.8	0	64	80	139
22 1/16/64	1	0.10	0.09	0.18	2.4	6	1.0	0.1	0.00	5.0	14	0.8	6.9	0	14	26	54
23 1/10/63	1	0.05	...	0.10	13.0	32	...	0.5	0.00	5.0	25	0.5	8.0	0	118	132	221
2/7/63	0	0.05	0.10	0.10	14.0	33	...	1.0	0.00	5.0	22	0.3	7.9	0	124	138	235
3/6/63	1	0.10	0.05	0.15	14.0	34	...	1.7	0.00	5.0	15	0.4	7.8	0	124	140	230
4/9/63	4	0.10	0.05	0.12	9.7	26	1.5	1.6	0.00	4.0	13	0.8	7.6	0	92	106	178
1/30/64	1	0.05	0.04	0.10	11.0	32	2.5	0.6	0.00	5.0	13	0.1	7.6	0	114	126	216
24 (a) 1/30/64	1	0.08	0.02	0.18	6.8	21	2.5	1.4	0.00	4.5	25	0.7	7.4	0	56	80	145
24 (b) 9/11/62	13	0.10	0.10	0.10	15.0	33	...	0.2	0.00	4.0	27	0.5	8.1	0	122	144	254
1/10/63	0	0.10	0.10	0.15	14.0	27	...	0.5	0.00	4.0	38	0.8	7.8	0	98	124	206
2/7/63	0	0.10	0.10	0.10	15.0	31	...	0.7	0.00	5.0	37	0.3	7.8	0	116	138	240
3/6/63	0	0.10	0.10	0.15	15.0	32	...	1.3	0.00	5.0	32	0.3	7.8	0	116	142	240
4/9/63	3	0.15	0.05	0.10	5.8	17	1.5	1.5	0.00	3.0	17	1.8	7.6	0	52	66	123
9/17/63	...	...	0.04	0.12	16.0	34	5.0	...	...	3.5	28	0.4	8.3	3	132	152	266
1/30/64	1	0.09	0.03	0.18	10.0	25	3.0	1.3	0.00	4.0	31	0.6	7.6	0	76	104	180
25 (a) 9/11/62	16	0.10	0.10	0.20	2.4	6	...	0.3	0.00	15.0	17	1.0	7.5	0	13	24	53
4/23/63	4	...	0.10	0.20	1.9	6	2.5	...	...	3.0	13	1.5	7.1	0	12	22	48
25 (b) 4/23/63	6	...	0.01	0.18	1.7	4	1.5	...	...	3.0	14	2.2	7.0	0	8	18	36
26 3/7/63	0	0.10	0.10	0.15	9.7	25	...	1.0	0.00	5.0	25	0.9	7.4	0	78	102	173
1/30/64	1	0.05	0.03	0.14	7.8	22	3.0	1.7	0.00	4.0	30	0.8	7.3	0	58	86	156
27 3/7/63	0	0.15	0.05	0.10	8.3	20	...	0.9	0.00	6.0	24	0.5	7.6	0	66	84	149
1/20/64	1	0.08	0.06	0.10	7.3	18	4.0	0.7	0.00	5.0	24	0.7	7.5	0	54	76	142
8/24/64	...	...	...	0.28	6.8	16	4.0	0.8	0.00	2.5	8	2.4	7.6	0	50	68	107
Marquette County, Mich.																	
29 2/28/63	0	0.15	0.10	0.25	11.0	42	5.0	3.1	0.00	7.0	65	0.6	7.4	0	96	148	288
7/29/63	21	...	0.04	0.50	5.3	37	8.5	...	...	4.0	37	...	8.0	0	90	114	245
1/20/64	1	0.11	0.03	0.22	10.0	38	11.0	2.1	0.00	2.0	47	0.5	7.5	0	94	136	269
30 2/28/63	0	0.15	0.10	0.30	2.9	10	...	0.6	0.00	4.0	18	1.2	7.1	0	30	38	67
1/10/64	0	0.05	0.00	0.30	1.9	10	1.0	0.6	0.00	3.0	5	1.1	7.4	0	24	32	59

Table 10.--Continued

County, state, stream number, and date		Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
31	1/10/64	0	0.11	0.04	0.25	3.4	22	1.5	0.5	0.00	7.5	8	0.5	7.4	0	58	68	120
	8/9/65	22	0.04	0.05	0.09	3.9	19	1.0	0.1	0.00	4.5	10	0.3	8.0	0	56	64	111
34	3/14/63	0	0.15	0.10	0.25	4.4	18	...	0.8	0.00	8.0	8	0.4	7.6	0	56	64	109
	1/28/64	0	0.07	0.06	0.23	3.9	17	0.5	1.1	0.00	9.0	8	0.6	7.6	0	50	58	101
35	3/14/63	0	0.10	0.10	0.15	3.9	19	...	0.4	0.00	7.0	8	0.6	7.6	0	54	64	108
	1/28/64	1	0.04	0.10	0.15	3.9	16	0.5	0.4	0.00	5.0	7	0.6	7.6	0	48	56	98
36	8/13/63	15	...	0.05	0.18	4.4	21	1.0	...	...	6.5	5	...	7.6	0	66	70	125
	1/28/64	0	0.06	0.07	0.10	3.4	18	0.5	0.7	0.00	9.0	4	0.4	7.5	0	56	60	108
37	8/13/63	22	...	0.07	0.10	2.9	13	1.0	...	...	3.5	5	...	7.3	0	36	44	80
	1/28/64	1	0.05	0.05	0.09	3.4	14	1.0	0.4	0.00	5.0	6	0.4	7.4	0	42	50	88
38	11/19/63	3	0.18	0.04	0.50	3.4	14	1.5	0.3	0.00	6.0	6	0.9	7.2	0	38	48	82
39	11/19/63	4	0.14	0.07	0.19	2.9	10	2.0	0.5	0.00	5.0	12	1.3	7.2	0	24	36	67
	1/22/64	1	0.08	0.04	0.16	4.4	12	1.5	0.8	0.00	6.0	8	0.6	7.3	0	32	48	78
	10/19/65	13	0.10	0.04	0.28	2.9	11	1.5	0.3	0.00	4.5	11	1.5	7.0	0	28	40	72
Baraga County, Mich.																		
40	1/22/64	1	0.12	0.02	0.28	2.2	12	4.0	0.7	0.00	5.0	11	0.8	7.4	0	30	38	80
	9/22/64	14	...	...	0.11	2.9	16	2.5	...	...	3.5	7	0.7	7.7	0	46	52	89
41	1/22/64	1	0.10	0.05	0.22	3.6	15	1.0	0.5	0.00	6.0	11	0.6	7.6	0	42	52	93
	9/22/64	13	...	...	0.08	3.9	18	0.5	...	...	6.0	4	0.4	8.1	0	54	60	106
42	1/16/63	0	0.20	...	0.30	3.4	15	...	0.7	0.00	7.0	18	0.7	7.4	0	44	52	94
	2/6/63	0	0.10	...	0.30	3.9	18	...	0.7	0.00	8.0	17	0.4	7.7	0	54	60	109
	3/5/63	0	0.10	...	0.30	3.9	19	...	1.0	0.00	9.0	18	0.6	7.7	0	58	64	117
	4/4/63	1	0.22	0.05	0.20	1.9	5	1.0	1.3	0.00	3.0	10	2.1	7.1	0	12	20	35
	1/22/64	1	0.13	0.01	0.26	5.8	18	1.5	0.6	0.00	5.5	8	0.9	7.6	0	54	70	112
43	1/22/64	1	0.02	0.03	0.13	6.3	26	1.5	0.9	0.00	9.0	10	0.4	7.6	0	80	90	154
	9/22/64	14	...	...	0.18	5.8	27	1.5	...	...	5.0	6	0.7	8.4	2	86	92	160
44	8/2/62	18	...	...	0.50	...	...	...	...	...	9.0	17	1.0	7.8	0	62	66	120
	6/18/63	21	...	0.08	0.18	5.3	23	0.0	...	...	9.0	4	0.5	7.9	0	78	80	147

Table 10.--Continued

County, state, stream number, and date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Houghton County, Mich.																	
45 (a) 9/5/62	15	...	0.10	0.30	8.7	28	...	0.1	0.00	8.0	20	0.9	7.6	0	96	106	178
1/16/63	0	0.25	0.10	0.30	4.4	17	...	0.9	0.00	6.0	18	1.4	7.4	0	54	60	108
2/6/63	0	0.15	0.10	0.35	5.3	20	...	1.0	0.00	8.0	19	1.2	7.6	0	64	72	125
3/5/63	0	0.15	...	0.35	14.0	49	15.0	2.0	0.00	15.0	37	2.1	7.9	0	158	180	403
4/4/63	2	0.22	0.05	0.25	2.9	10	1.5	1.6	0.00	3.5	7	1.9	7.2	0	30	38	69
6/18/63	15	...	0.03	0.30	3.4	12	1.5	...	...	2.0	1	2.7	7.5	0	36	44	72
1/27/64	1	0.10	0.03	0.22	6.3	25	2.0	0.8	0.00	8.0	8	0.8	7.4	0	82	88	160
45 (b) 9/3/63	19	...	0.06	0.26	5.3	25	3.0	...	...	5.0	5	...	7.6	0	76	84	146
1/27/64	1	0.07	0.01	0.30	5.8	23	3.0	0.9	0.00	7.0	8	0.9	7.6	0	76	82	150
45 (c) 3/13/63	0	0.10	0.10	0.15	21.0	72	45.0	1.5	0.00	25.0	15	1.2	8.0	0	244	266	557
3/26/63	0	0.10	0.10	0.20	5.3	23	3.5	1.5	0.00	7.0	6	1.1	7.8	0	76	80	154
6/18/63	13	...	0.04	0.22	5.8	19	1.0	...	...	4.0	2	2.2	7.8	0	64	72	118
1/27/64	1	0.15	0.05	0.42	9.7	30	1.0	0.5	0.00	10.0	2	0.5	7.6	0	116	116	216
45 (d) 3/13/63	0	0.05	0.10	0.10	31.0	54	65.0	3.0	0.02	31.0	42	1.1	8.6	10	234	264	624
3/26/63	0	0.15	0.10	0.20	4.9	21	4.0	1.4	0.00	8.0	4	0.7	7.7	0	64	72	133
6/18/63	13	...	0.07	0.22	4.9	18	3.0	...	...	6.0	1	1.6	7.8	0	56	66	110
1/27/64	1	0.11	0.06	0.22	6.3	25	4.0	0.8	0.00	11.0	6	0.6	7.8	0	82	88	167
46 8/2/62	...	0.10	...	0.10	7.8	30	5.0	...	...	8.0	22	0.2	8.3	4	81	108	208
1/27/64	1	0.08	0.00	0.03	5.8	30	12.0	3.2	0.01	8.0	14	0.6	7.7	0	76	98	190
47 (a) 8/4/63	18	...	0.10	0.10	6.3	55	94.0	...	...	10.0	8	...	7.9	0	70	164	398
1/20/64	1	0.09	0.10	0.20	5.8	42	59.0	2.0	0.00	8.0	9	0.1	7.5	0	56	130	293
47 (b) 8/4/63	17	...	0.04	0.16	5.3	20	3.0	...	...	10.0	5	...	8.0	0	66	72	130
47 (c) 8/4/63	17	...	0.09	0.20	6.3	126	287.0	...	...	9.0	13	...	7.7	0	70	340	942
48 8/2/63	17	...	0.08	0.10	5.1	17	4.0	...	...	7.5	10	...	7.8	0	44	64	105
49 (a) 9/22/64	14	...	...	0.75	3.9	14	1.5	...	...	6.0	3	2.1	7.3	0	40	52	96
5/24/65	16	...	0.03	0.58	2.1	6	1.0	1.5	0.00	0.5	0	4.8	6.8	0	12	24	37
49 (b) 5/12/64	14	...	...	0.23	1.5	6	2.0	...	...	1.5	11	3.0	6.8	0	8	20	36
50 5/12/64	14	...	...	0.38	2.4	4	2.0	...	...	1.0	9	1.4	6.9	0	10	20	35

Table 10.--Continued

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
51	8/2/63	20	...	0.05	0.70	4.9	15	2.0	...	...	7.0	3	...	7.8	0	57	58	109
	1/20/64	0	0.21	0.07	0.40	3.9	14	1.5	0.5	0.00	7.5	9	0.8	7.4	0	46	52	101
	5/13/64	9	...	...	0.28	2.9	6	2.0	...	...	2.0	5	2.6	6.8	0	16	28	46
52	5/12/64	11	...	...	0.09	2.4	11	2.5	...	...	7.0	13	0.8	7.1	0	26	38	74
53	5/12/64	10	...	...	0.12	1.9	10	2.0	...	...	3.5	9	1.5	7.2	0	25	34	60
54	5/12/64	11	...	...	0.14	2.4	11	1.0	...	...	6.0	13	1.0	7.1	0	25	38	65
55	8/2/62	...	...	0.10	0.00	5.8	25	...	...	...	8.0	25	0.0	7.9	0	75	86	166
56	8/2/62	...	...	0.10	0.10	5.3	23	...	...	...	9.0	30	0.0	7.6	0	70	80	157
57	8/3/62	...	0.10	...	0.00	...	26	...	...	...	11.0	18	0.0	...	...	...	...	...
	1/13/64	0	0.05	0.08	0.05	4.4	26	2.0	4.1	0.00	12.0	12	0.1	7.9	0	70	84	152
58	8/3/62	13	0.10	0.10	...	4.9	22	...	...	...	6.0	15	0.0	7.9	0	69	74	136
	9/5/63	16	...	0.09	0.14	4.9	22	2.0	...	...	9.0	6	...	7.8	0	70	74	131
	1/13/64	0	0.03	0.08	0.19	4.9	21	1.5	1.5	0.00	11.0	9	0.2	7.6	0	64	72	146
59	9/5/63	11	...	0.08	0.10	4.4	24	2.5	...	...	10.0	4	...	8.1	0	76	78	135
60	1/13/64	0	0.10	0.03	0.09	3.9	20	1.0	1.6	0.00	10.0	4	0.3	7.7	0	62	66	123
	9/9/64	...	...	...	0.02	3.9	18	1.0	...	...	7.0	2	1.2	8.1	0	56	62	110
Keweenaw County, Mich.																		
61	1/20/64	0	0.19	0.05	0.53	3.9	11	1.0	0.7	0.00	6.0	8	1.4	7.2	0	34	44	77
62	1/20/64	0	0.08	0.03	0.17	2.9	9	2.0	0.3	0.00	3.0	5	0.6	7.3	0	28	34	62
	9/22/64	14	...	...	0.03	2.4	10	0.5	...	...	3.5	10	0.6	7.5	0	28	34	69
	5/24/65	16	...	0.05	0.09	3.4	6	1.0	0.2	0.00	2.0	6	1.1	7.3	0	20	30	44
63	1/20/64	0	0.08	0.06	0.37	3.4	18	5.5	0.5	0.00	8.0	13	0.4	7.4	0	50	60	111
64	1/20/64	0	0.10	0.02	0.16	4.4	13	3.5	0.7	0.00	5.0	7	0.7	7.5	0	38	50	91
	10/19/65	12	0.07	0.04	0.15	3.9	17	11.0	0.4	0.00	8.0	4	1.6	7.3	0	42	58	117
65	6/18/63	...	...	0.19	0.12	4.4	44	55.0	...	...	10.0	7	...	7.3	0	68	128	307

Table 10.--Continued

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhoa/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Ontonagon County, Mich.																		
66 (a)	8/3/62	...	0.10	...	0.10	10.0	34	...	...	...	9.0	15	0.0	...	0	119	126	221
	8/20/62	16	...	...	0.20	9.7	34	...	0.0	0.00	9.0	15	0.2	8.3	0	120	126	221
	8/28/62	16	0.10	...	0.20	10.0	34	...	0.3	0.00	10.0	22	0.2	8.3	0	119	128	225
	9/27/62	9	0.10	...	0.20	7.3	30	...	0.2	0.00	9.0	22	0.8	7.9	0	100	106	192
	1/13/64	0	0.11	0.04	0.20	7.3	30	2.5	0.8	0.00	9.0	8	0.6	7.8	0	98	104	184
66 (b)	9/27/62	...	0.10	...	0.20	9.2	33	...	0.2	0.00	8.0	19	0.7	7.8	0	110	120	208
66 (c)	9/27/62	...	0.10	...	0.20	7.8	31	...	0.1	0.00	8.0	26	0.7	7.7	0	105	110	195
67	1/21/64	0	0.11	0.01	0.28	6.3	22	3.5	0.5	0.00	5.0	2	0.0	7.5	0	74	82	147
	9/9/64	...	...	...	0.15	5.3	18	3.0	...	...	3.0	12	1.9	8.0	0	56	68	117
68	1/21/64	0	0.06	0.08	0.31	5.8	26	13.0	0.9	0.00	5.0	17	0.4	7.2	0	68	88	176
69 (a)	1/21/64	0	0.02	0.09	0.19	5.8	20	1.5	1.2	0.00	7.0	9	0.1	7.7	0	64	74	139
69 (b)	7/2/63	26	...	0.03	0.15	4.4	15	2.0	...	...	3.0	3	...	7.7	0	46	56	91
	1/21/64	1	0.04	0.07	0.12	4.9	18	1.5	1.3	0.00	5.0	8	0.1	7.6	0	58	64	119
69 (c)	7/2/63	22	...	0.01	0.10	6.8	26	1.5	...	...	6.0	4	...	7.9	0	88	92	163
	1/21/64	0	0.03	0.04	0.08	14.0	41	3.0	2.5	0.00	16.0	13	0.1	8.1	0	156	160	283
69 (d)	7/2/63	22	...	0.01	0.20	4.9	23	1.5	...	...	5.0	5	...	7.8	0	74	78	136
	1/21/64	0	0.08	0.02	0.19	4.9	21	1.5	2.0	0.00	10.0	10	0.1	7.6	0	68	72	132
69 (e)	7/5/63	13	...	0.08	0.20	5.3	19	1.0	...	...	9.0	6	...	7.8	0	64	70	132
69 (f)	7/5/63	13	...	0.05	0.14	4.1	17	1.0	...	...	6.0	4	...	7.8	0	54	59	108
69 (g)	7/5/63	14	...	0.09	0.10	5.8	26	1.5	...	...	11.0	5	...	8.0	0	86	88	158
70	1/29/64	0	0.12	0.05	0.35	5.3	30	8.5	0.4	0.00	4.0	11	0.4	7.4	0	86	96	188
71	1/29/64	0	0.10	0.08	0.37	8.7	42	30.0	1.4	0.00	8.0	24	1.2	7.6	0	106	142	317
72	1/29/64	0	0.11	0.09	0.32	7.8	41	75.0	2.3	0.01	9.0	30	1.4	7.9	0	90	134	422
73	1/29/64	0	0.10	0.08	0.25	3.4	19	16.0	0.7	0.00	6.5	13	0.6	7.6	0	40	62	137
74	1/29/64	0	0.09	0.03	0.20	3.9	27	24.0	0.5	0.00	5.0	11	0.1	7.5	0	50	84	176

Table 10.--Continued

County, state, stream number, and date		Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Gogebic County, Mich.																		
75	1/23/64	1	0.09	0.09	0.40	5.3	22	1.5	0.8	0.00	11.0	5	0.2	7.4	0	76	78	146
76	1/23/64	1	0.16	0.04	0.43	5.3	22	5.0	2.3	0.00	8.5	17	1.0	7.5	0	64	78	155
77	1/23/64	0	0.17	0.01	0.39	6.3	37	45.0	2.4	0.01	12.0	15	0.7	7.5	0	58	118	267
Ashland County, Wis.																		
78 (a)	5/23/63	11	...	...	0.30	...	...	1.5	...	...	...	4	...	7.5	0	46	56	88
78 (b)	1/22/63	0	0.25	0.10	0.40	6.3	22	...	1.9	0.00	13.0	20	0.7	7.4	0	74	80	149
	2/18/63	0	0.18	...	0.40	6.3	22	...	1.7	0.00	14.0	20	0.6	7.5	0	76	82	154
	4/1/63	4	0.20	0.10	0.20	2.9	9	2.0	1.4	0.00	4.0	6	1.6	7.2	0	22	34	62
	5/23/63	9	...	...	0.30	...	...	1.5	...	...	...	3	...	7.5	0	36	46	72
	12/11/63	0	0.05	0.05	0.10	5.3	18	2.5	1.3	0.00	8.0	13	0.9	7.6	0	54	67	120
	2/10/64	0	0.10	0.06	0.36	16.0	59	6.0	2.7	0.00	22.0	22	1.6	8.0	0	202	212	370
	9/29/64	11	...	...	0.27	4.4	15	2.5	...	...	3.5	18	3.1	7.5	0	36	56	94
78 (c)	5/23/63	10	...	...	0.25	...	...	2.0	...	...	...	3	...	7.5	0	18	32	49
	12/11/63	0	0.08	0.02	0.11	4.4	15	3.0	2.1	0.00	5.0	12	1.4	7.6	0	40	56	105
	2/10/64	0	0.11	0.04	0.36	4.9	19	2.0	1.3	0.00	11.0	11	1.0	7.6	0	62	68	124
	9/29/64	11	...	...	0.30	4.9	11	2.5	...	...	3.0	17	4.2	7.2	0	22	48	71
78 (d)	5/23/63	12	...	...	0.25	...	...	1.5	...	...	...	3	...	7.5	0	70	74	130
78 (e)	12/11/63	0	0.05	0.07	0.13	5.8	26	1.5	1.4	0.00	9.0	6	0.1	7.9	0	86	88	135
	2/10/64	0	0.04	0.09	0.12	6.3	27	2.0	0.4	0.00	13.0	8	0.5	7.5	0	92	94	168
	9/29/64	11	...	...	0.21	6.3	23	1.5	...	...	6.0	6	1.7	7.9	0	80	84	150
78 (f)	5/23/63	9	...	...	0.30	...	...	1.0	...	...	...	6	...	7.3	0	49	56	97
	12/11/63	0	0.07	0.06	0.08	6.3	23	1.0	1.8	0.00	11.0	7	0.3	8.0	0	82	84	151
	2/10/64	0	0.02	0.08	0.23	86.0	115	540.0	4.2	0.06	32.0	92	4.3	8.3	6	522	644	2,452
	3/16/64	0	0.10	0.06	0.28	6.3	21	4.0	3.8	0.00	8.0	9	1.8	7.6	0	72	78	152
	9/29/64	11	...	...	0.28	6.8	22	1.5	...	...	6.5	5	1.4	7.8	0	76	82	146
78 (g)	3/16/64	2	0.10	0.06	0.28	5.8	24	2.0	2.2	0.00	11.0	5	1.0	7.5	0	84	84	156
78 (h)	3/16/64	0	0.05	0.05	0.24	5.3	20	4.0	3.0	0.00	6.0	6	2.2	7.6	0	70	72	148

Table 10.--Continued

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
78 (i)	5/23/63	10	...	...	0.20	...	20	1.0	...	...	...	4	...	7.0	0	20	44	49
	12/11/63	0	0.04	0.03	0.14	3.9	13	1.5	1.0	0.00	4.5	8	0.8	7.8	0	38	48	86
	2/10/64	0	0.08	0.10	0.31	5.3	15	2.0	1.0	0.00	9.0	12	1.0	7.7	0	54	60	113
	3/16/64	1	0.08	0.06	0.26	4.4	15	1.5	1.4	0.00	9.0	12	1.0	7.2	0	50	56	104
	9/29/64	13	...	...	0.28	4.4	10	1.0	...	...	3.5	7	2.0	7.4	0	28	44	67
78 (j)	5/23/63	9	...	...	0.20	...	...	1.5	...	...	...	3	...	7.4	0	23	40	54
	12/11/63	0	0.13	0.00	0.10	3.9	12	2.0	2.0	0.00	2.5	13	1.6	7.5	0	30	46	82
	2/10/64	0	0.09	0.04	0.40	4.4	18	2.0	0.9	0.00	10.0	9	1.0	7.6	0	54	62	114
	9/29/64	10	...	...	0.31	4.9	11	2.0	...	...	3.5	19	3.6	7.2	0	22	48	73
78 (k)	5/23/63	10	...	...	0.20	...	...	2.0	...	...	...	2	...	7.4	0	22	34	51
	12/11/63	0	0.07	0.09	0.12	3.9	10	2.5	1.9	0.00	3.5	16	1.4	7.4	0	26	42	77
	2/10/64	0	0.10	0.04	0.23	3.9	17	2.5	1.2	0.00	11.0	13	0.8	7.7	0	52	58	110
	9/29/64	11	...	...	0.29	3.9	14	3.5	...	...	4.0	23	2.7	7.4	0	28	50	88
Bayfield County, Wis.																		
79	1/6/64	0	0.04	0.02	0.11	5.8	20	1.0	0.4	0.00	12.0	5	0.0	8.0	0	74	74	138
80	1/6/64	0	0.05	0.08	0.16	4.9	18	1.0	0.3	0.00	12.0	4	0.0	8.0	0	64	66	118
81	1/6/64	0	0.06	0.06	0.18	7.8	26	0.7	0.1	0.00	12.0	1	0.0	8.0	0	98	98	164
	10/14/64	14	...	...	0.17	8.7	26	1.5	...	...	8.0	7	0.4	8.1	0	98	102	188
82	1/6/64	0	0.04	0.05	0.05	4.9	22	0.5	0.3	0.00	12.0	3	0.0	8.0	0	74	74	133
83	1/6/64	0	0.06	0.02	0.13	4.9	17	1.5	0.1	0.00	12.0	2	0.0	7.8	0	60	62	113
84	1/6/64	0	0.04	0.02	0.11	5.8	22	3.5	1.6	0.00	12.0	5	0.0	7.8	0	76	78	148
85	12/2/63	0	0.07	0.04	0.20	5.8	20	1.0	0.3	0.00	8.0	7	0.4	7.9	0	74	74	144
86	12/2/63	0	0.04	0.07	0.10	13.0	40	1.5	0.7	0.00	11.0	12	0.4	8.1	0	152	154	269
	10/14/64	12	...	...	0.10	10.0	34	2.5	...	...	8.0	7	1.0	8.2	0	123	128	235
87	12/2/63	0	0.15	0.06	0.50	14.0	43	4.0	0.2	0.00	9.0	18	0.8	8.0	0	162	166	298
	10/14/64	12	...	...	0.53	6.3	20	4.0	...	...	2.0	3	5.0	7.7	0	67	76	138

Table 10.--Continued

County, state, stream number, and date	Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.³ at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Douglas County, Wis.																	
88 (a) 1/22/63	0	0.10	0.10	0.10	4.9	17	...	0.6	0.00	13.0	17	0.0	7.6	0	60	62	119
2/18/63	0	0.05	...	0.10	4.9	16	...	0.5	0.00	12.0	18	0.2	7.8	0	56	60	111
4/1/63	7	0.15	0.05	0.20	4.4	13	2.5	0.6	0.00	7.0	5	1.3	7.5	0	40	50	84
12/2/63	0	0.06	0.09	0.14	4.9	18	1.5	0.3	0.00	11.0	7	0.1	7.5	0	62	64	120
7/8/65	18	0.02	0.06	0.15	5.3	16	2.0	0.2	0.00	8.5	8	0.8	8.0	0	56	62	106
88 (b) 7/8/65	14	0.05	0.05	0.09	4.4	15	2.0	0.2	0.00	11.0	5	1.0	8.1	0	52	56	100
88 (c) 7/8/65	13	0.03	0.04	0.17	4.4	14	2.5	0.5	0.00	11.0	6	1.4	7.7	0	48	52	92
88 (d) 7/8/65	16	0.03	0.01	0.22	4.4	14	1.5	0.5	0.00	5.5	9	1.6	7.5	0	44	52	90
89 12/4/63	1	0.11	0.02	0.30	6.8	18	6.5	3.4	0.00	8.0	21	1.9	7.6	0	52	74	144
90 12/4/63	2	0.14	0.03	0.55	7.3	21	7.0	2.2	0.00	7.0	25	2.0	7.8	0	62	82	162
91 12/4/63	2	0.12	0.03	0.65	5.6	17	4.0	1.0	0.00	4.0	13	1.5	7.7	0	58	66	130
92 (a) 12/4/63	2	0.12	0.05	0.45	12.0	34	4.0	1.2	0.00	9.0	35	1.1	7.9	0	110	132	237
92 (b) 12/4/63	2	0.28	0.03	0.70	5.8	14	3.0	1.2	0.00	4.0	14	3.0	7.3	0	46	60	120
St. Louis County, Minn.																	
93 1/8/64	1	0.31	0.01	0.07	8.7	30	17.0	2.1	0.00	6.0	28	8.8	7.5	0	76	112	231
Lake County, Minn.																	
94 1/8/64	1	0.05	0.00	0.13	7.8	23	8.5	1.9	0.00	7.0	12	0.2	8.0	0	72	90	170
95 1/8/64	1	0.14	0.09	0.55	6.3	24	5.5	2.0	0.00	11.0	13	0.4	8.0	0	74	86	166
10/16/64	15	...	...	0.38	5.3	16	3.0	...	...	4.0	10	1.9	7.7	0	44	62	108
96 1/8/64	1	0.15	0.08	0.37	4.4	13	2.0	2.4	0.00	10.0	8	1.2	7.8	0	36	50	87
Cook County, Minn.																	
97 1/8/64	1	0.08	0.08	0.31	2.9	8	2.0	1.8	0.00	9.0	6	0.5	7.7	0	26	32	63
98 1/8/64	1	0.09	0.04	0.13	3.4	7	1.0	1.1	0.00	6.5	4	0.6	7.7	0	26	32	61
99 1/8/64	1	0.07	0.09	0.30	3.9	8	2.0	1.4	0.00	7.0	8	0.5	7.6	0	22	32	58
10/16/64	12	...	...	0.25	2.9	6	2.5	...	...	3.0	3	2.0	7.4	0	13	26	42

Table 11.--Water quality of streams tributary to Lake Michigan, 1962-65

[Stream numbers correspond to those assigned to streams in the text and figure 2. Letters in parentheses indicate more than one location on a stream was sampled.]

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.³ at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Mackinac County, Mich.																		
1 (a)	2/4/64	1	0.09	0.05	0.15	9.2	34	1.5	0.4	0.00	8.0	37	0.3	7.5	0	80	122	203
1 (b)	2/4/64	1	0.03	0.08	0.19	9.7	27	0.7	0.8	0.00	7.0	12	0.2	7.8	0	96	108	185
1 (c)	2/4/64	1	0.16	0.08	0.52	7.8	29	0.7	0.7	0.00	6.0	6	0.8	7.8	0	96	104	176
2	2/4/64	3	0.24	0.09	0.90	9.7	36	1.0	0.5	0.00	4.0	4	1.2	7.9	0	122	130	214
3	2/4/64	3	0.07	0.05	0.23	9.7	34	1.5	0.3	0.00	7.0	6	0.5	8.0	0	116	124	207
4	2/5/64	0	0.11	0.06	0.28	9.2	36	1.0	0.4	0.00	5.0	10	0.5	7.7	0	120	128	213
5	2/5/64	0	0.09	0.00	0.10	6.3	31	1.5	1.2	0.00	3.0	24	0.7	7.6	0	80	104	175
6 (a)	2/5/64	0	0.20	0.07	0.61	6.3	30	1.0	0.9	0.00	4.5	17	1.2	7.7	0	82	100	166
6 (b)	2/5/64	0	0.12	0.00	0.20	10.0	31	1.5	1.3	0.00	3.0	27	0.8	7.7	0	92	120	202
7 (a)	2/12/64	2	0.12	0.04	0.30	4.4	18	1.0	0.3	0.00	4.0	5	0.3	7.3	0	58	64	115
7 (b)	2/12/64	1	0.15	0.04	0.40	4.9	16	1.0	0.6	0.00	5.0	10	0.4	7.4	0	52	60	107
8 (a)	2/12/64	2	0.05	0.07	0.16	9.2	37	2.0	0.8	0.00	6.5	25	0.3	7.6	0	110	130	223
8 (b)	2/12/64	1	0.08	0.05	0.22	9.7	45	6.0	1.2	0.00	5.0	51	1.0	7.5	0	102	152	264
	5/15/65	14	...	...	...	8.3	32	1.5	...	...	...	...	...	7.3	0	88	114	174
8 (c)	2/12/64	1	0.07	0.06	0.12	9.2	34	2.0	1.0	0.00	4.0	39	0.9	7.5	0	82	124	202
	5/15/65	13	...	...	...	8.3	23	1.5	...	...	...	...	...	7.2	0	60	92	130
Schoolcraft County, Mich.																		
9	2/26/64	1	0.11	0.09	0.23	10.0	46	2.0	1.5	0.00	5.0	17	1.1	7.6	0	130	156	254
10	2/26/64	1	0.05	0.05	0.16	12.0	34	4.0	0.7	0.00	3.0	27	1.0	7.5	0	102	134	228
11	2/26/64	1	0.04	0.06	0.02	14.0	34	6.5	0.3	0.00	0.0	19	0.4	7.8	0	112	142	232

Table 11.--Continued

County, state, stream number, and date		Temper-ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alka-linity	Total hard-ness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
12 (a)	2/26/64	1	0.14	0.03	0.22	12.0	43	2.5	2.6	0.00	5.5	24	1.3	7.8	0	130	156	250
	9/13/65	21	0.02	0.06	0.00	23.0	72	13.0	0.4	0.00	17.0	57	0.9	8.4	2	222	276	413
12 (b)	2/26/64	1	0.08	0.06	0.12	16.0	50	5.0	1.1	0.00	6.0	58	1.5	7.7	0	122	194	312
13	3/3/64	2	0.18	0.08	0.70	5.8	34	2.0	0.7	0.00	6.0	36	1.0	7.4	0	76	110	194
14	3/3/64	4	0.04	0.05	0.15	11.0	34	3.0	0.8	0.00	4.5	12	0.5	7.8	0	116	128	218
15	3/11/64	1	0.06	0.07	0.14	7.3	28	2.0	2.5	0.00	5.0	19	1.1	7.4	0	84	100	174
16 (a)	3/11/64	0	0.04	0.06	0.05	11.0	29	1.0	0.8	0.00	4.0	14	0.5	7.7	0	104	116	195
16 (b)	3/11/64	0	0.02	0.06	0.03	8.7	34	1.0	0.6	0.00	5.0	8	0.3	7.7	0	110	120	200
17	3/11/64	1	0.35	0.03	1.10	7.8	20	1.5	1.7	0.00	3.0	7	2.3	7.5	0	66	82	132
	9/13/65	12	0.10	0.03	0.04	15.0	42	8.0	0.3	0.00	3.0	10	1.4	8.1	0	154	168	269
18	3/11/64	1	0.05	0.03	0.38	16.0	39	1.5	1.0	0.00	5.5	12	0.9	7.9	0	152	162	264
19	3/11/64	0	0.11	0.06	0.45	8.3	20	1.5	1.5	0.00	5.5	13	1.0	7.7	0	70	84	146
Delta County, Mich.																		
20	3/3/64	1	0.12	0.04	0.50	6.3	18	1.5	2.3	0.00	3.5	21	1.6	7.4	0	50	70	128
21	3/3/64	1	0.14	0.05	0.63	10.0	33	2.0	0.9	0.00	8.0	46	1.5	7.4	0	84	126	220
	6/22/65	18	0.20	0.04	0.90	9.2	26	2.0	1.0	0.00	1.5	18	3.4	7.7	0	80	104	164
22	3/3/64	1	0.08	0.05	0.46	9.7	32	1.5	0.6	0.00	6.0	27	1.0	7.6	0	94	120	201
	6/22/65	17	0.17	0.05	0.83	8.3	28	1.5	0.9	0.00	3.0	20	2.6	7.9	0	84	104	167
23 (a)	1/30/63	0	0.20	0.10	0.70	8.3	31	...	0.5	0.00	7.0	22	0.8	7.4	0	96	112	192
	2/20/63	0	0.20	0.10	0.70	7.8	30	...	0.8	0.00	8.0	28	0.6	7.6	0	92	106	187
	3/19/63	0	0.20	0.10	0.65	7.8	30	...	0.9	0.00	7.0	18	0.9	7.6	0	92	108	184
	4/10/63	2	0.25	0.05	0.50	4.9	12	1.5	1.6	0.00	3.0	15	2.5	7.1	0	30	50	79
	5/6/63	13	...	...	0.70	6.3	20	1.5	...	...	...	12	...	7.4	0	60	76	122
	3/12/64	0	0.20	0.10	1.00	6.3	29	2.0	0.6	0.00	8.0	19	0.9	7.4	0	84	98	175
23 (b)	5/6/63	13	...	...	0.80	4.9	19	1.0	...	...	...	6	...	7.3	0	54	68	109
23 (c)	3/12/64	1	0.31	0.06	1.60	4.4	26	1.0	0.6	0.00	5.0	9	1.1	7.5	0	78	82	146
23 (d)	4/30/63	5	...	...	0.50	4.9	18	1.0	...	...	...	5	...	7.3	0	52	64	106

Table 11.--Continued

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol-phthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
24	3/12/64	0	0.29	0.05	0.86	6.3	21	1.0	0.9	0.00	6.0	20	1.9	7.4	0	60	78	129
25	3/12/64	0	0.25	0.03	0.90	8.7	32	4.5	1.7	0.00	3.5	27	1.7	7.5	0	90	116	201
26	3/12/64	1	0.09	0.02	0.34	5.8	20	2.5	0.9	0.00	5.0	19	0.6	7.3	0	60	74	136
27 (a)	1/30/63	0	0.10	0.10	0.20	15.0	39	...	1.0	0.00	6.0	24	0.5	7.8	0	146	160	250
	2/20/63	0	0.10	0.10	0.25	14.0	38	...	1.4	0.00	6.0	24	0.3	7.9	0	140	152	250
	3/19/63	0	0.10	0.10	0.30	14.0	36	...	1.3	0.00	6.0	15	0.6	7.9	0	136	148	248
	4/10/63	2	0.06	0.05	0.20	7.8	20	2.0	1.1	0.00	3.0	21	1.6	7.6	0	64	82	135
	2/6/64	1	0.08	0.06	0.20	9.7	30	1.5	0.8	0.00	6.0	21	0.7	7.5	0	98	116	181
	3/18/64	0	...	0.03	0.15	14.0	36	2.0	1.5	0.00	4.5	19	0.9	7.8	0	118	146	232
	6/3/65	14	0.07	0.04	0.21	9.7	31	1.5	...	0.00	2.0	3	1.9	8.2	0	106	118	188
27 (b)	2/6/64	1	0.06	0.08	0.29	12.0	38	1.0	1.0	0.00	6.0	17	0.5	7.8	0	128	146	240
	3/18/64	0	...	0.05	0.25	12.0	37	1.0	1.2	0.00	6.0	16	0.5	7.9	0	126	142	230
	6/3/65	13	0.05	0.03	0.23	11.0	35	1.0	...	0.00	3.0	11	1.6	8.2	0	120	134	216
27 (c)	2/6/64	1	0.07	0.02	0.09	13.0	32	2.0	1.1	0.00	4.0	28	0.8	7.8	0	108	134	219
	3/18/64	0	...	0.06	0.88	16.0	41	7.0	3.2	0.00	8.0	37	2.1	7.6	0	138	166	298
	6/2/65	11	0.08	0.07	0.22	8.7	27	2.0	0.9	0.00	1.5	5	1.8	8.2	0	92	104	168
27 (d)	3/18/64	0	...	0.04	0.64	7.8	31	1.5	0.9	0.00	6.0	9	1.1	7.8	0	98	110	186
	6/3/65	12	0.19	0.05	0.19	5.8	18	1.5	...	0.00	0.5	1	3.4	8.0	0	56	70	107
27 (e)	3/18/64	0	...	0.06	0.08	15.0	40	2.0	2.7	0.00	4.0	25	0.7	7.7	0	136	162	269
	6/2/65	11	0.05	0.07	0.17	12.0	31	1.0	1.2	0.00	2.0	3	1.4	8.1	0	110	126	197
27 (f)	3/17/64	0	...	0.06	0.08	16.0	30	1.0	1.8	0.00	4.5	29	0.9	7.8	0	102	138	214
	6/2/65	11	0.03	0.06	0.01	11.0	26	1.0	0.8	0.00	1.5	5	1.4	7.9	0	96	110	168
27 (g)	3/17/64	0	...	0.04	0.06	16.0	44	1.0	1.7	0.01	4.5	18	0.7	7.9	0	164	178	293
	6/2/65	11	0.02	0.09	0.13	14.0	37	1.0	0.5	0.00	3.0	14	1.1	8.3	0	130	150	230
27 (h)	3/17/64	0	...	0.08	0.12	15.0	40	1.5	1.7	0.01	5.5	24	0.7	7.9	0	142	162	274
	6/2/65	11	0.00	0.05	0.12	12.0	34	1.0	0.9	0.00	1.5	3	1.2	8.2	0	120	134	211
27 (i)	3/17/64	0	0.16	0.05	0.33	4.6	8	1.5	1.0	0.00	6.0	17	2.2	6.7	0	21	40	63
	6/3/65	12	0.12	0.01	0.18	4.4	7	1.0	...	0.00	0.0	4	3.4	7.2	0	18	36	39
27 (j)	3/17/64	0	...	0.05	0.15	12.0	23	1.5	0.9	0.00	5.0	28	1.5	7.3	0	72	108	159
	6/3/65	12	0.08	0.02	0.15	7.3	18	1.0	...	0.00	0.5	1	2.4	8.0	0	64	76	119

Table 11.--Continued

County, state, stream number, and date		Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
28 (a)	2/6/64	1	0.00	0.04	0.12	15.0	40	25.0	...	0.00	10.0	33	2.8	7.4	0	108	160	331
28 (b)	2/27/64	1	0.05	0.03	0.11	6.3	44	2.0	1.9	0.00	4.5	27	1.2	7.8	0	106	136	223
29	2/27/64	1	0.07	0.04	0.05	11.0	47	3.0	2.4	0.00	7.0	28	0.4	7.9	0	138	164	279
30	8/20/62	...	0.10	0.00	0.10	11.0	32	...	...	...	3.0	17	0.4	8.3	2	108	126	211
	8/28/62	16	0.10	0.02	0.20	11.0	30	...	0.1	0.00	4.0	19	0.3	8.3	0	108	120	203
	9/5/62	17	0.15	0.02	0.30	9.2	31	...	0.5	0.00	3.0	25	1.2	7.9	0	94	116	194
	1/30/63	0	0.10	0.10	0.25	12.0	37	...	0.9	0.00	8.0	20	0.3	7.8	0	126	140	235
	2/20/63	0	0.13	0.10	0.20	11.0	34	...	1.2	0.00	7.0	23	0.2	7.9	0	116	128	211
	3/19/63	0	0.10	0.10	0.25	11.0	33	...	1.6	0.00	8.0	24	0.4	7.8	0	112	128	213
	4/10/63	2	0.10	0.05	0.10	6.8	24	2.0	1.2	0.00	3.0	24	1.4	7.7	0	64	88	144
	3/10/64	0	0.08	0.07	0.21	11.0	43	8.0	2.1	0.00	6.0	30	1.0	7.7	0	132	154	276
31	3/10/64	0	0.05	0.06	0.32	9.7	29	2.0	1.1	0.00	8.0	15	0.3	7.8	0	96	112	189
32	3/2/64	2	0.40	0.08	1.20	7.3	38	14.0	3.9	0.05	5.0	32	2.2	7.5	0	125	126	302
34	4/20/63	3	...	0.10	0.15	6.3	19	2.0	...	...	4.0	19	1.2	7.2	0	48	74	118
35	2/27/64	1	0.05	0.04	0.16	19.0	82	6.0	4.1	0.00	11.0	34	1.1	7.8	0	246	286	470
Menominee County, Mich.																		
36 (a)	1/24/63	0	0.10	0.10	0.20	22.0	69	...	1.0	0.00	10.0	29	1.1	7.7	0	240	262	403
	2/27/63	0	0.07	0.05	0.20	21.0	68	...	1.3	0.00	10.0	24	1.1	7.9	0	234	256	422
	3/28/63	0	0.10	0.05	0.20	8.7	31	3.0	2.3	0.00	5.0	20	1.3	7.7	0	100	114	199
	3/2/64	0	0.01	0.09	0.17	23.0	69	3.5	0.8	0.00	8.0	25	1.4	7.7	0	242	266	389
36 (b)	3/2/64	0	0.07	0.04	0.07	19.0	55	3.5	2.0	0.01	5.0	23	1.9	7.7	0	188	216	360
36 (c)	3/2/64	1	0.07	0.05	0.21	27.0	66	10.0	0.5	0.00	9.0	25	1.5	7.6	0	254	276	451
37	4/16/63	4	...	0.10	0.10	7.8	26	2.0	...	...	1.0	13	1.4	7.5	0	74	96	151
	2/27/64	1	0.14	0.05	0.50	19.0	81	1.5	0.3	0.00	8.0	29	0.9	7.5	0	250	280	451
38	4/16/63	2	...	0.10	0.15	6.3	23	2.0	...	...	2.0	19	1.2	7.1	0	58	84	131
39	4/16/63	2	...	0.10	0.10	9.2	26	3.5	...	...	2.0	23	1.1	7.2	0	70	104	149
	2/24/64	0	0.14	0.04	0.43	41.0	91	14.0	1.1	0.00	13.0	45	2.8	7.6	0	348	400	634
40	4/16/63	1	...	0.10	0.05	8.3	20	2.5	...	...	2.0	21	1.1	7.3	0	58	84	131

Table 11.--Continued

County, state, stream number, and date		Temper- ature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^-	NO_3^-	NO_2^-	SiO_2	$SO_4^=$	Tannin and lignin	pH	Phenol- phthalein alkalinity	Total alka- linity	Total hard- ness	Conductivity (micromhos/cm.[3] at 18° C.)
		° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
41	4/16/63	4	...	0.08	0.10	14.0	40	2.5	...	...	1.0	32	1.2	7.6	0	116	156	230
	2/24/84	0	0.09	0.05	0.23	20.0	66	2.5	0.3	0.00	12.0	24	1.3	7.9	0	222	252	403
42	4/16/63	4	...	0.10	0.10	9.7	43	3.0	...	...	1.0	22	1.3	7.7	0	122	148	235
	2/24/64	0	0.08	0.04	0.12	20.0	68	7.0	0.7	0.00	12.0	32	1.2	7.8	0	224	254	418
43	2/24/64	0	0.07	0.07	0.12	11.0	37	3.5	0.5	0.00	10.0	28	2.5	7.4	0	114	136	238
Marinette County, Wis.																		
44	2/10/64	0	0.06	0.09	0.10	11.0	44	1.5	1.6	0.00	11.0	15	0.2	7.8	0	144	154	261
Oconto County, Wis.																		
45	2/10/64	1	0.14	0.04	0.22	12.0	47	11.0	...	0.00	7.0	27	14.0	7.2	0	138	168	302
Door County, Wis.																		
47	4/12/63	3	...	...	...	26.0	50	...	...	...	...	...	...	7.8	0	210	232	374
	2/24/64	0	0.02	0.07	0.01	32.0	63	2.0	2.3	0.00	4.0	30	1.0	8.0	0	258	288	442
48	4/12/63	7	...	...	...	27.0	57	...	...	...	...	...	...	7.9	0	244	256	408
	2/24/64	0	0.04	0.10	0.13	31.0	65	3.5	4.4	0.01	5.0	33	1.4	7.9	0	252	290	451
49	4/12/63	7	...	...	...	24.0	45	...	...	...	...	...	...	8.0	0	188	212	346
	2/24/64	0	0.03	0.06	0.03	34.0	48	5.0	1.2	0.00	6.0	29	0.8	8.1	0	230	260	413
50	4/12/63	7	...	...	...	27.0	59	...	...	...	...	...	...	7.9	0	226	262	416
	2/24/64	1	0.00	0.07	0.10	31.0	62	4.0	5.0	0.00	6.0	28	0.9	7.9	0	246	282	442
51	4/12/63	7	...	...	...	30.0	63	...	...	...	...	...	...	8.0	0	240	282	446
	2/24/64	1	0.10	0.06	0.23	33.0	70	3.5	2.2	0.00	10.0	53	1.1	8.0	0	250	308	490
Kewaunee County, Wis.																		
53	2/10/64	0	0.04	0.06	0.02	35.0	74	6.0	3.6	0.01	10.0	62	0.9	7.5	0	272	328	518
	3/30/64	1	...	0.06	0.16	35.0	67	5.5	2.9	0.01	11.0	55	1.3	7.9	0	252	312	499
	4/16/64	5	...	0.04	0.08	31.0	70	6.5	2.3	0.01	7.0	66	1.6	8.0	0	226	302	480
54	2/10/64	0	0.03	0.06	0.13	34.0	72	9.5	4.3	0.02	10.0	60	1.2	7.8	0	262	318	538

Table 11.--Continued

County, state, stream number, and date	Temperature	Al	Cu	Fe	Mg^{++}	Ca^{++}	Cl^{-}	NO_3^{-}	NO_2^{-}	SiO_2	$SO_4^{=}$	Tannin and lignin	pH	Phenolphthalein alkalinity	Total alkalinity	Total hardness	Conductivity (micromhos/cm.[3] at 18° C.)
	° C.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.		P.p.m. as $CaCO_3$			
Manitowoc County, Wis.																	
55 2/10/64	2	0.02	0.09	0.14	33.0	70	7.5	4.2	0.01	9.5	67	0.9	7.9	0	248	312	518
Manistee County, Mich.																	
56 (a) 9/25/63	11	...	0.09	0.11	11.0	42	14.0	...	...	6.0	31	...	8.0	0	126	150	269
56 (b) 9/25/63	11	...	0.08	0.11	12.0	40	9.5	...	...	5.0	14	...	8.0	0	134	150	254

Concentrations of magnesium, calcium, chlorides, total alkalinity, and total hardness, and values of pH and conductivity generally varied inversely with the flow. They were lowest during spring runoff and heavy rains, and highest during low flow in late summer and the colder periods of winter. Exceptions were the Ahnapee and Pensaukee Rivers, tributaries to Lake Michigan, where calcium, total alkalinity, total hardness, and conductivity decreased from late spring and summer to lowest values in August and September when flows were stable or slowly receding.

Chlorides varied more in tributaries to Lake Superior than in tributaries to Lake Michigan. In the Lake Superior tributaries, chlorides ranged from 0.0 to 540.0 p.p.m., usually 0.5 to 5.0 p.p.m. The extremely high value of 540.0 p.p.m. was recorded in the Marengo River, a major tributary of the Bad River, on February 10, 1964, when the flow was low. During more usual flows, chloride concentrations there were 1.0 to 1.5 p.p.m. Other tributaries of the Bad River did not have high chloride concentrations. A high chloride value of 6.0 p.p.m. also was found at one station on the Bad River below the confluence of the Marengo River on February 10, 1964.

High concentrations of chloride also were recorded in Scales Creek (287.0 p.p.m.), a tributary of the Traprock River, and Hill Creek (55.0 p.p.m.) of the Lake Superior drainage. The high chloride values in these streams did not appear during low flow. The two creeks, which drain opposite sides of the same ridge, may be affected by copper mining in the area.

Concentrations of chlorides were higher than usual on a few streams in Ontonagon and Gogebic Counties of the Lake Superior drainage in late winter during periods of low flow. Magnesium, calcium, total hardness, and conductivity values also were high when the chloride content was high.

The range for chlorides was 0.7 to 25.0 p.p.m., usually 1.0 to 14.0 p.p.m. in Lake Michigan tributaries. The high value of 25.0 p.p.m. was obtained at one station on the Rapid River. The water at this station was affected by discharge of waste from a milk-processing plant located upstream. Above this plant the chloride concentration was lower.

Nitrites were found at a few stations.

All streams were alkaline with the exception of Five Mile Creek (pH 6.9), Mud Lake Inlet (pH 6.8), Mud Lake Outlet (pH 6.8), and Rice Lake Outlet (pH 6.9), tributaries to Lake Superior, and the upper portion of Werners Creek (pH 6.7), a tributary to the Whitefish River that flows into Lake Michigan. These streams are small and have flows less than 1.0 $m.^3/sec.$ (35 c.f.s.).

The pH was lowest during the spring runoff when streams that normally are alkaline may become acid for short periods. The pH slowly rose to a peak in August or September. With the onset of winter, the pH fell until spring. The pH may be high when flows are extremely low in late winter.

Phenolphthalein alkalinity was seldom found in Lake Superior tributaries. It was detected when flows were low in late winter and late summer in Seven Mile Creek and Rock, Falls, Otter, Pilgrim, and Marengo Rivers.

Ahnapee and Pensaukee Rivers of Lake Michigan had phenolphthalein alkalinity from April to November, and it was present in some samples from the Ford River, Days River, and Marblehead Creek.

Temperature records for many of the streams discussed in this report are available from the Bureau of Commercial Fisheries Biological Station at Marquette, Mich., for dates other than those shown on the tables.

CAUSES OF CHANGES IN WATER QUALITY

Water quality of the streams changed throughout a year and from year to year. The values of the various measurements varied with the flow, temperature, and season of the year.

The quality of stream water was influenced by various natural and manmade causes. Natural factors that affected the water quality in a given area were flow of the stream, elevation of the water table, turbulence, shade from vegetation, and variable influences of tributary streams. The water quality also was influenced by the physical and chemical characteristics of the ground topography of the stream bed and drainage. Man affected the water quality through industrial wastes, domestic sewage, changes in land use, and impoundments of water behind dams.

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APPENDIX

STREAMS AND SAMPLING LOCATIONS

(*Designates the stream where more than one location was sampled)

Lake Superior:

Chippewa County, Mich.:

1. Waiska River - M-28 bridge, T. 46 N., R. 2 W., on south line of sec. 15.
2. Pendills Creek - Lake Shore Drive, T. 47 N., R. 4 W., sec. 28.
3. Grants Creek - Lake Shore Drive, T. 47 N., R. 5 W., sec. 13.
4. Halfaday Creek - Lake Shore Drive bridge, T. 47 N., R. 5 W., sec. 14.
5. Naomikong Creek - Lake Shore Drive, T. 47 N., R. 5 W., sec. 19.
6. Ankodosh Creek - Lake Shore Drive, T. 47 N., R. 6 W., sec. 14.
7. Roxbury Creek - East and West Road bridge, T. 47 N., R. 6 W., sec. 14.
8. Galloway Creek - M-123 bridge, T. 48 N., R. 6 W., sec. 29.

*9. Tahquamenon River -
   (a) M-123 bridge, T. 48 N., R. 6 W., sec. 15;
   (b) M-117 bridge, T. 46 N., R. 10 W., on east line of sec. 23.

10. Betsy River - Wire Road bridge, T. 49 N., R. 6 W., sec. 3.

Luce County, Mich.:

11. Little Two Hearted River - Fisher Bridge, T. 49 N., R. 9 W., sec. 12.

*12. Two Hearted River -
   (a) weir site, T. 50 N., R. 9 W., sec. 27;
   (b) East Branch - East Branch bridge, T. 49 N., R. 9 W., sec. 18;
   (c) Highbridge on County Road 407, T. 49 N., R. 10 W., sec. 31;
   (d) North Branch - County Road 418 bridge, T. 58 N., R. 11 W., sec. 1;
   (e) South Branch - Hemlock Dam, T. 48 N., R. 11 W., sec. 21;
   (f) Dawson Creek - County Road 412 bridge, T. 48 N., R. 10 W., sec. 5.

13. Dead Sucker River - Grand Marais truck trail, T. 49 N., R. 12 W., sec. 1.

Alger County, Mich.:

*14. Sucker River -
   (a) Graham Bridge on County Road 703, T. 49 N., R. 13 W., on east line of sec. 33;
   (b) School Forest bridge, T. 49 N., R. 13 W., sec. 2;
   (c) Grand Marais Creek - County Road 700 bridge, T. 49 N., R. 13 W., sec. 10.

15. Hurricane River - County Road 700 bridge, T. 49 N., R. 15 W., sec. 10.
16. Sullivans Creek - County Road 700 bridge, T. 49 N., R. 15 W., sec. 9.
17. Seven Mile Creek - old bridge, T. 49 N., R. 16 W., sec. 11.
18. Mosquito River - Mosquito Falls, T. 48 N., R. 17 W., sec. 31.
19. Miners River - U.S.F.S. Road 2489 bridge, T. 47 N., R. 18 W., sec. 10.
20. Anna River - M-28 bridge, T. 46 N., R. 19 W., sec. 11.
21. Furnace Creek - M-28 bridge, T. 47 N., R. 19 W., sec. 29.
22. Five Mile Creek - U.S.F.S. Road 2491 bridge, T. 47 N., R. 19 W., sec. 18.
23. Au Train River - first bridge below lake, T. 46 N., R. 20 W., sec. 5.

*24. Rock River -
   (a) M-28 bridge, T. 47 N., R. 21 W., sec. 15;
   (b) U.S.F.S. Road 2279 bridge, T. 46 N., R. 21 W., sec. 15.

*25. Deer Lake -
   (a) outlet, M-28 bridge, T. 47 N., R. 21 W., sec. 8;
   (b) inlet, T. 47 N., R. 21 W., sec. 7.

26. Laughing Whitefish River - bridge, T. 47 N., R. 22 W., sec. 3.
27. Sand River - County Road 480 bridge, T. 47 N., R. 23 W., on south line of sec. 14.

Marquette County, Mich.:

*28. Chocolay River -
   (a) U.S. 41 bridge, T. 46 N., R. 24 W., sec. 1;
   (b) Big Creek - U.S. 41 bridge, T. 47 N., R. 24 W., sec. 16;
   (c) Cedar Creek - U.S. 41 bridge, T. 47 N., R. 24 W., sec. 17;
   (d) Cherry Creek - U.S. 41 bridge, T. 47 N., R. 24 W., sec. 8.

29. Carp River - 100 yards above M-28 bridge, T. 48 N., R. 25 W., sec. 36.
30. Dead River - County Road 550 bridge, T. 48 N., R. 25 W., sec. 10.
31. Harlow Creek - County Road 550 bridge, T. 49 N., R. 25 W., sec. 19.
32. Little Garlic River - County Road 550 bridge, T. 49 N., R. 26 W., sec. 3.

*33. Big Garlic River -
   (a) County Road 550 bridge, T. 50 N., R. 26 W., sec. 33;
   (b) Wilson Creek - above junction of Sawmill Creek, T. 50 N., R. 26 W., sec. 29;

*33. Big Garlic River - (cont.)
(c) Sawmill Creek - County Road 550 bridge, T. 50 N., R. 26 W., sec. 29.
34. Yellow Dog River - County Road 550 bridge, T. 51 N., R. 26 W., sec. 31.
35. Iron River - below Lake Independence, T. 51 N., R. 27 W., sec. 13.
36. Salmon Trout River - County Road 550 bridge, T. 51 N., R. 28 W., sec. 1.
37. Pine River - County Road 550 bridge, T. 52 N., R. 28 W., sec. 21.
38. Little Huron River - T. 52 N., R. 29 W., sec. 29.
39. Huron River - Big Eric's bridge, T. 52 N., R. 30 W., sec. 35.

Baraga County, Mich.:
40. Ravine River - Skanee Road bridge, T. 51 N., R. 31 W., sec. 4.
41. Slate River - Skanee Road bridge, T. 51 N., R. 31 W., sec. 8.
42. Silver River - Skanee Road bridge, T. 51 N., R. 32 W., sec. 24.
43. Falls River - U.S. 41 bridge, T. 50 N., R. 33 W., sec. 5.
44. Six Mile Creek - U.S. 41 bridge, T. 50 N., R. 34 W., sec. 1.

Houghton County, Mich.:
*45. Sturgeon River -
(a) M-35 bridge, T. 51 N., R. 34 W., sec. 28;
(b) U.S. 41 bridge, T. 53 N., R. 33 W., sec. 4;
(c) West Branch - Pelkie Road bridge, T. 51 N., R. 34 W., on east line of sec. 20;
(d) Otter River - Pelkie Road bridge, T. 51 N., R. 34 W., on east line of sec. 8.
46. Pilgrim River - U.S. 41 bridge, T. 54 N., R. 33 W., sec. 5.
*47. Traprock River -
(a) below junction with Scales Creek, T. 56 N., R. 32 W., on south line of sec. 16;
(b) above junction with Scales Creek, T. 56 N., R. 32 W., sec. 10;
(c) Scales Creek - bridge, T. 56 N., R. 32 W., sec. 9.
48. McCallum Creek - bridge, T. 55 N., R. 32 W., sec. 20.
*49. Mud Lake -
(a) inlet, bridge, T. 55 N., R. 32 W., sec. 34;
(b) outlet, bridge, T. 55 N., R. 32 W., sec. 25.
50. Rice Lake - outlet, bridge, T. 55 N., R. 31 W., sec. 20.
51. Traverse River - Gay-Lake Linden Road bridge, T. 56 N., R. 31 W., sec. 28.
52. Smith Creek - bridge, T. 56 N., R. 34 W., sec. 13.
53. Seven Mile Creek - M-203 bridge, T. 56 N., R. 34 W., sec. 24.
54. Bear Creek - M-203 bridge, T. 56 N., R. 34 W., sec. 23.
55. Lily Creek - M-203 bridge, T. 56 N., R. 34 W., sec. 34.
56. Boston Creek - M-203 bridge, T. 56 N., R. 34 W., sec. 34.
57. Schlotz Creek - mouth, T. 55 N., R. 34 W., sec. 8.
58. Salmon Trout River - mouth, T. 55 N., R. 35 W., sec. 20.
59. Graveraet River - mouth, T. 55 N., R. 36 W., sec. 35.
60. Elm River - bridge on section line, T. 54 N., R. 36 W., sec. 34.

Keweenaw County, Mich.:
61. Tobacco River - mouth, T. 56 N., R. 30 W., sec. 20.
62. Little Gratiot River - old weir site, T. 58 N., R. 29 W., sec. 31.
63. Eliza Creek - mouth, T. 57 N., R. 30 W., sec. 6.
64. Gratiot River - bridge, T. 57 N., R. 32 W., on east line of sec. 19.
65. Hill Creek - mouth, T. 57 N., R. 33 W., sec. 14.

Ontonagon County, Mich.:
*66. Misery River -
(a) bridge, T. 53 N., R. 37 W., sec. 15;
(b) North Branch - mouth, T. 53 N., R. 37 W., sec. 25;
(c) above junction with North Branch, T. 53 N., R. 37 W., sec. 25.
67. Firesteel River - bridge, T. 52 N., R. 38 W., sec. 7.
68. Flintsteel River - bridge, T. 52 N., R. 39 W., sec. 14.
*69. Ontonagon River -
(a) Victoria Bridge, T. 50 N., R. 39 W., sec. 20;
(b) West Branch - Victoria Dam, T. 50 N., R. 39 W., sec. 29;
(c) Middle Branch - mouth, T. 50 N., R. 39 W., sec. 27;
(d) East Branch - mouth, T. 50 N., R. 39 W., sec. 27;
(e) Jumbo River - gravel pit, T. 47 N., R. 37 W., sec. 22;
(f) Middle Branch - M-28 bridge, T. 47 N., R. 38 W., sec. 8;
(g) Trout Creek - U.S.F.S. Road 208 bridge, T. 48 N., R. 38 W., sec. 35.
70. Potato River - M-64 bridge, T. 52 N., R. 40 W., sec. 33.
71. Cranberry River - M-64 bridge, T. 51 N., R. 40 W., sec. 5.
72. Iron River - M-107 bridge, T. 51 N., R. 42 W., sec. 12.
73. Little Iron River - M-107 bridge, T. 51 N., R. 42 W., sec. 11.
74. Union River - M-107 bridge, T. 51 N., R. 42 W., sec. 15.

Gogebic County, Mich.:
75. Presque Isle River - M-28 bridge, T. 48 N., R. 44 W., sec. 23.

76. Black River - bridge, T. 48 N., R. 46 W., on east line of sec. 32.
77. Montreal River - County Road 505 bridge, T. 48 N., R. 49 W., sec. 15.

Ashland County, Wis.:

*78. Bad River -
(a) U.S. 2 bridge, T. 48 N., R. 3 W., sec. 25;
(b) T. 47 N., R. 3 W., sec. 1;
(c) Highway 169 bridge, T. 45 N., R. 2 W., sec. 32;
(d) White River - mouth, T. 48 N., R. 3 W., sec. 26;
(e) White River - Highway 13 bridge, T. 47 N., R. 4 W., sec. 26;
(f) Marengo River - Highway 13 bridge, T. 46 N., R. 4 W., sec. 36;
(g) Marengo River - County Road C bridge, T. 46 N., R. 4 W., sec. 31;
(h) Marengo River - bridge, T. 46 N., R. 3 W., sec. 33;
(i) Brunsweiler River - Highway 13 bridge, T. 45 N., R. 4 W., sec. 1;
(j) Tyler Forks, T. 45 N., R. 2 W., sec. 16;
(k) Potato River - Highway 169 bridge, T. 46 N., R. 1 W., on east line of sec. 17.

Bayfield County, Wis.:

79. Fish Creek (Eileen Township) - U.S. 2 bridge, T. 47 N., R. 5 W., sec. 2.
80. Sioux River - 1 mile above Highway 13, T. 49 N., R. 4 W., sec. 17.
81. Sand River - Highway 13 bridge, T. 51 N., R. 5 W., sec. 14.
82. Siskiwit River - bridge, T. 51 N., R. 6 W., sec. 35.
83. Cranberry River - Highway 13 bridge, T. 50 N., R. 7 W., sec. 8.
84. Flag River - bridge, T. 50 N., R. 8 W., on south line of sec. 27.
85. Iron River - old Highway 13 bridge, T. 49 N., R. 9 W., sec. 4.
86. Reefer Creek - old Highway 13 bridge, T. 49 N., R. 9 W., sec. 4.
87. Fish Creek (Orienta Township) - old Highway 13 bridge, T. 49 N., R. 9 W., sec. 5.

Douglas County, Wis.:

*88. Brule River -
(a) County Road FF bridge, T. 48 N., R. 10 W., on south line of sec. 15;
(b) County Road B bridge, T. 47 N., R. 10 W., sec. 34;
(c) County Road S bridge (Stones Bridge), T. 46 N., R. 10 W., sec. 30;
(d) Nebagamon Creek - bridge, T. 47 N., R. 10 W., sec. 27.
89. Poplar River - Highway 13 bridge, T. 48 N., R. 11 W., sec. 7.
90. Middle River - Highway 13 bridge, T. 48 N., R. 12 W., sec. 12.
91. Amnicon River - Highway 13 bridge, T. 48 N., R. 12 W., sec. 8.
*92. Nemadji River -
(a) bridge, T. 47 N., R. 14 W., sec. 4;
(b) Black River - bridge, T. 47 N., R. 14 W., on west line of sec. 4.

St. Louis County, Minn.:

93. St. Louis River - Highway 23 bridge, T. 48 N., R. 15 W., sec. 7.

Lake County, Minn.:

94. Stewarts River - U.S. 61 bridge, T. 53 N., R. 10 W., sec. 29.
95. Split Rock River - U.S. 61 bridge, T. 54 N., R. 8 W., sec. 7.
96. Baptism River - U.S. 61 bridge, T. 56 N., R. 7 W., sec. 15.

Cook County, Minn.

97. Temperance River - U.S. 61 bridge, T. 59 N., R. 4 W., sec. 32.
98. Devils Track River - U.S. 61 bridge, T. 61 N., R. 1 E., sec. 13.
99. Arrowhead River (Brule River) - U.S. 61 bridge, T. 62 N., R. 3 E., sec. 27.

Lake Michigan:

Mackinac County, Mich.:

*1. Brevort River -
(a) U.S. 2 bridge, T. 41 N., R. 5 W., sec. 9;
(b) Silver Creek - Federal Forest Highway 2 bridge, T. 42 N., R. 5 W., on south line of sec. 17;
(c) Little Brevort River - Federal Forest Highway 2 bridge, T. 42 N., R. 6 W., sec. 24.
2. Cut River - bridge above U.S. 2, T. 42 N., R. 6 W., sec. 7.
3. Paquin River - U.S. 2 bridge, T. 42 N., R. 7 W., sec. 6.
4. Davenport Creek - U.S. 2 bridge, T. 42 N., R. 8 W., sec. 2.
5. Hog Island Creek - U.S. 2 bridge, T. 43 N., R. 8 W., sec. 34.
*6. Black River -
(a) old weir site, T. 43 N., R. 8 W., sec. 30;
(b) East Branch - mouth, T. 43 N., R. 8 W., sec. 29.
*7. East Mile Creek -
(a) U.S. 2 bridge, T. 43 N., R. 9 W., sec. 22;
(b) West Mile Creek - U.S. 2 bridge, T. 43 N., R. 9 W., sec. 21.
*8. Millecoquins River -
(a) County Road 930 bridge, T. 43 N., R. 10 W., sec. 14;
(b) Doe Creek - M-117 bridge, T. 43 N., R. 10 W., on west line of sec. 4;
(c) Furlong Creek - M-117 bridge, T. 43 N., R. 10 W., on east line of sec. 8.

Schoolcraft County, Mich.:

9. Milakokia River - County Road P 432 bridge, T. 41 N., R. 13 W., sec. 2.
10. Bulldog Creek - County Road P 432 bridge, T. 41 N., R. 13 W., sec. 4.

11. Gulliver Lake Outlet - first bridge below lake, T. 41 N., R. 14 W., sec. 2.

*12. Marblehead Creek -
(a) U.S. 2 bridge, T. 42 N., R. 15 W., sec. 36;
(b) Nelson Creek - U.S. 2 bridge, T. 42 N., R. 14 W., sec. 32.

13. Manistique River - U.S. 2 bridge, T. 41 N., R. 16 W., sec. 12.

14. Thompson Creek - U.S. 2 bridge, T. 41 N., R. 16 W., sec. 32.

15. Johnson Creek - County Road P 435 bridge, T. 40 N., R. 17 W., sec. 1.

*16. Deadhorse Creek -
(a) County Road P 435 bridge, T. 40 N., R. 17 W., sec. 14;
(b) Snyder Creek - County Road P 435 bridge, T. 40 N., R. 17 W., sec 12.

17. Bursaw Creek - County Road P 435 bridge, T. 40 N., R. 17 W., sec. 23.

18. Parent Creek - County Road P 435 bridge, T. 39 N., R. 17 W., sec. 4.

19. Poodle Pete Creek - County Road P 435 bridge, T. 39 N., R. 17 W., sec. 8.

Delta County, Mich.:

20. Valentine Creek - County Road 483 bridge, T. 40 N., R. 18 W., sec. 28.

21. Little Fishdam River - U.S. 2 bridge, T. 41 N., R. 18 W., sec. 33.

22. Fishdam River - U.S. 2 bridge, T. 41 N., R. 18 W., sec. 32.

*23. Sturgeon River -
(a) U.S. 2 bridge, T. 40 N., R. 19 W., sec. 6;
(b) Palos Camp, T. 43 N., R. 19 W., sec. 33;
(c) U.S.F.S. Road 2259 bridge, T. 44 N., R. 19 W., sec. 33;
(d) Graham Dam, T. 44 N., R. 20 W., sec. 1.

24. Ogontz River - U.S. 2 bridge, T. 41 N., R. 20 W., sec. 34.

25. Squaw Creek - County Road 513 bridge, T. 39 N., R. 22 W., sec. 12.

26. Hock Creek - County Road 513 bridge, T. 40 N., R. 21 W., sec. 7.

*27. Whitefish River -
(a) U.S. 2 bridge, T. 41 N., R. 21 W., sec. 28;
(b) East Branch - U.S.F.S. Road 2236 bridge, T. 43 N., R. 20 W., sec. 30;
(c) West Branch - County Road 444 bridge, T. 43 N., R. 21 W., sec. 9;
(d) Haymeadow Creek - County Road 509 bridge, T. 42 N., R. 20 W., sec. 19;
(e) Dexter Creek - bridge, T. 44 N., R. 21 W., on west line of sec. 13;
(f) Dexter Creek - bridge, T. 45 N., R. 21 W., on south line of sec. 30;
(g) Scotts Creek - bridge, T. 45 N., R. 22 W., sec. 35;
(h) Scotts Creek - M-67 bridge, T. 44 N., R. 21 W., sec. 19;
(i) Werner Creek - County Road 533 bridge, T. 44 N., R. 23 W., sec. 2;
(j) Werner Creek - mouth, T. 44 N., R. 21 W., sec. 30.

*28. Rapid River -
(a) U.S. 2 bridge, T. 41 N., R. 21 W., on south line of sec. 20;
(b) U.S. 41 bridge, T. 42 N., R. 21 W., sec. 19.

29. Tacoosh River - U.S. 41 bridge, T. 41 N., R. 21 W., sec. 19.

30. Days River - U.S. 2 bridge, T. 40 N., R. 22 W., sec. 2.

31. Escanaba River - T. 39 N., R. 23 W., sec. 1.

32. Portage Creek - M-35 bridge, T. 38 N., R. 23 W., sec. 1.

*33. Ford River -
(a) M-95 bridge, T. 43 N., R. 30 W., sec. 17;
(b) 1/4 mile above mouth, T. 38 N., R. 23 W., sec. 16;
(c) County Road 581 bridge, T. 43 N., R. 28 W., sec. 22;
(d) bridge, T. 41 N., R. 24 W., sec. 19.

34. Sunny Brook - M-35 bridge, T. 38 N., R. 23 W., sec. 20.

35. Bark River - M-35 bridge, T. 37 N., R. 24 W., sec. 27.

Menominee County, Mich.:

*36. Cedar River -
(a) weir site, T. 35 N., R. 25 W., sec. 11;
(b) County Road 551 at McCarty Bridge, T. 37 N., R. 25 W., on east line of sec. 22;
(c) U.S. 2 bridge, T. 38 N., R. 26 W., sec. 8.

37. Sugar Creek - M-35 bridge, T. 34 N., R. 25 W., sec. 4.

38. Rochereau Creek - M-35 bridge, T. 34 N., R. 25 W., sec. 31.

39. Johnson Creek - M-35 bridge, T. 33 N., R. 26 W., sec. 1.

40. Bailey Creek - M-35 bridge, T. 33 N., R. 26 W., sec. 14.

41. Beattie Creek - M-35 bridge, T. 33 N., R. 26 W., sec. 28.

42. Springer Creek - M-35 bridge, T. 32 N., R. 26 W., sec. 7.

43. Menominee River - T. 32 N., R. 28 W., sec. 14.

Marinette County, Wis.:

44. Peshtigo River - County Road W bridge, T. 31 N., R. 21 E., sec. 28.

Oconto County, Wis.:

45. Oconto River - U.S. 141 bridge, T. 28 N., R. 20 E., sec. 34.

46. Pensaukee River - U.S. 141 bridge, T. 27 N., R. 20 E., sec. 26.

Door County, Wis.:

47. Ephraim Creek - mouth, T. 31 N., R. 27 E., sec. 23.

48. Hibbards Creek - mouth, T. 29 N., R. 27 E., sec. 14.
49. Whitefish Bay Creek - mouth, T. 28 N., R. 27 E., sec. 15.
50. Lily Bay Creek - County Road T bridge, T. 27 N., R. 27 E., sec. 6.
51. Bear Creek - mouth, T. 26 N., R. 26 E., sec. 28.

Kewaunee County, Wis.:

52. Ahnapee River - County Road J bridge, T. 26 N., R. 25 E., on south line of sec. 29.
53. Three Mile Creek - Highway 42 bridge, T. 24 N., R. 25 E., sec. 10.
54. Kewaunee River - County Road F bridge, T. 23 N., R. 24 E., sec. 23.

Manitowoc County, Wis.:

55. East Twin River - Highway 147 bridge, T. 20 N., R. 24 E., sec. 4.

Manistee County, Mich.:

*56. Little Manistee River -
(a) M-37 bridge, T. 19 N., R. 13 W., sec. 11;
(b) bridge, T. 21 N., R. 16 W., sec. 21.

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